Learner Manual

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Level 3 Certificate in Personal Training

Contents

Unit One
Anatomy and Physiology for Health and Exercise

Anatomy and Physiology for Health and Exercise

Aim: to provide the learner with all the relevant information regarding anatomy and physiology and the workings of the human body to support the role of a fitness professional in advising and guiding clients in exercise and health.

Learning outcomes

At the end of this unit the learner will understand:

- the heart and circulatory system and its relation to exercise and health
- the musculoskeletal system and its relation to exercise postural and core stability
- the nervous system and its relation to exercise
- the endocrine system and its relation to exercise
- energy systems and their relation to exercise

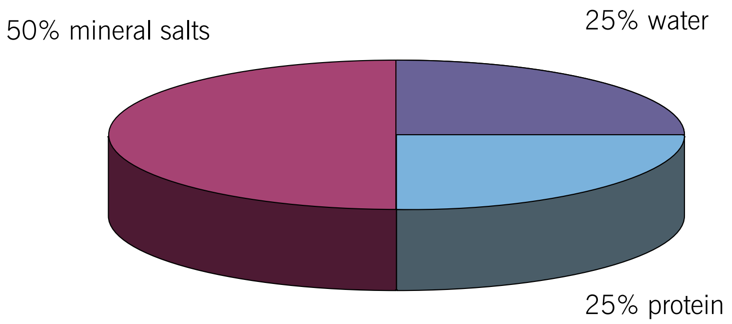
The skeletal system

The skeletal system is the foundation on which all movement is based. Knowledge of its structure and function will, therefore, allow a greater understanding of exercise. This section will cover the following areas:

- the physiology of bone tissue
- classification and structure of bones
- the anatomy of the skeleton
- the vertebral column

Bone physiology

Bone consists of a mixture of water, protein and mineral salts, the latter of which constitutes roughly 50% of its structure. Bone strength is the result of a combination of the hardness of these minerals combined with the tensile properties of collagen (derived from protein). Too little of one (e.g. collagen) and the bone will shatter like an egg shell, too little of the other (e.g. mineral salts) and bone will bend like a piece of rubber.



Ossification: the process of bone formation

Although bone is rigid, it behaves like any other living tissue, constantly being broken down, rebuilt and adapting to the stresses placed on it (Meyers, 2001). The process of bone formation is called ossification and as Tortora and Grabowski (1996) note, it begins in the womb and continues throughout adult life.

The hardening and growth process involves replacing a cartilage 'framework' with mineral salts. Bones of young children are softer than those of adults because they still contain significant proportions of cartilage. The hardening process may not be complete until 30 years of age. So, in early life, the emphasis of ossification is very much on bone growth and bone hardening, whereas the process in adulthood is more geared towards replacing and maintaining existing bone material. Whilst there is quite a diversity of cells involved in the bone formation process, the primary cells involved in bone growth are osteoblasts, which function to replace worn out or damaged bone tissue. Their activity is coordinated with that of the osteoclast cells, which remove the old bony tissue.

Maintenance of a healthy skeletal system is dependant upon a balance of osteoblast and osteoclast activity. This can vary according to the region of bone concerned; the end of the femur for example, can be completely remodelled every few months, which contrasts with the bone shafts which may never be fully remodelled (Tortora and Graboswki, 1996).

It is also worth noting that remodelling will tend to follow the lines of stress placed upon the bone (Meyers, 2001). Exercise and habitual posture therefore, have a fundamental influence over the health of the skeletal system. Incorrect exercise technique coupled with a generally poor alignment, will lead to a remodelling process that may reinforce the predominating bad posture (Meyers, 2001; Schultz and Feitis, 1996).

Hormonal regulation of bone

In the pre-puberty years, bone formation is predominantly regulated by human growth hormone (HGH) produced by the pituitary gland (located in the brain). At puberty however, testosterone produced by the male testes and oestrogen produced by the female ovaries begin to exert a greater influence. In women, oestrogen promotes growth of the skeleton and development of the unique female skeletal characteristics (i.e. the broader pelvis). Testosterone on the other hand, causes males to have larger more robust skeletons (McArdle et al, 2001).

Further aspects of bone growth are discussed with respect to the structure of a long bone.

The skeletal system and calcium regulation

Although calcium provides the skeletal system with rigidity it is also involved in a number of other important functions. These include muscular contraction, transmission of nervous impulses and regulating fluid balance (McArdle et al.,1996; Jones and Round, 1991). Too much or too little calcium in the body can easily upset these processes, thus bones act as calcium reservoirs which can either take up or release calcium depending on the body's needs (Jones and Rounds, 1990; Tortora and Grabowski, 1996). When calcium is scarce it will be withdrawn from the bones, which is why diets that are chronically low in calcium tend to increase the risk of osteoporosis.

Osteoporosis: brittle bone disease: bone remodelling is a delicate balance of osteoblast and osteoclast activity. Osteoporosis is caused by an imbalance in this process, whereby osteoblast activity decreases causing a drop in bone growth. This leads to a gradual loss in bone density and ultimately gives rise to a skeletal system that is unable to withstand the forces placed upon it.

There may be a number of causes of the condition; however one of the biggest is the drop in oestrogen levels associated with the menopause. This makes women significantly more likely to develop the condition than men. In men, a proportion of circulating testosterone (which is produced throughout life) is converted into oestrogen and this is thought to provide men with significant protection against loss of bone mass.

Low calorific intake and/or overtraining also increase the risk of osteoporosis in females by depleting body fat stores which are one of the primary sources of oestrogen. Poor quality diets which are lacking in or have an imbalance of minerals and vitamins also increase the risks by limiting the availability of calcium (Tortora and Grabowski, 1996). The table below provides a summary of some of the risk factors associated with osteoporosis.

Osteoporosis risk factors:

- female sex – due to drop in oestrogen levels (particularly at the menopause)
- calcium deficiency – through poor diet or poor absorption
- lack of exercise
- smoking – causes a drop in oestrogen levels
- family history
- certain drugs, such as alcohol which interrupt normal hormonal and calcium regulation
- low body fat
- overtraining

(McArdle et al., 2001; Tortora and Grabowski, 1996; National Institutes of Health Osteoporosis and Related Bone Disease)

The classification and structure of bone

Compact and cancellous bone

Bone tissue varies in arrangement and depending on its location and functions, comes in two forms; compact and cancellous. Compact bone has a relatively high density of bone matter. It forms the external surfaces of bones, predominates in the shafts of long bones and serves to resist compressive forces.

Cancellous bone in comparison is relatively more porous and if viewed closely has a spongy appearance. It predominates in the interior of bones and especially at bone ends (epiphyses). The spaces within the cancellous bone form a vital function by housing red marrow, which is responsible for red blood cell production.

Classification of bone

Bones can be categorised according to their shape and will generally fall into four or five shape categories; long, short, flat, irregular and sesamoid:

- long bones – have a greater length than width and consist of a shaft with normally two extremities. They contain mostly cancellous bone in their epiphysis and more compact bone in their diaphysis (see diagram), and principally act as levers. These include the humerus, femur, fibula, tibia, ulna, radius, metacarpals, metatarsals and phalanges.

- short bones – have a cubed appearance and are predominantly cancellous bone with an outer shell of compact bone. These include the carpals (except for the pisiform - sesamoid) and the tarsals (except for the calcaneus - irregular).

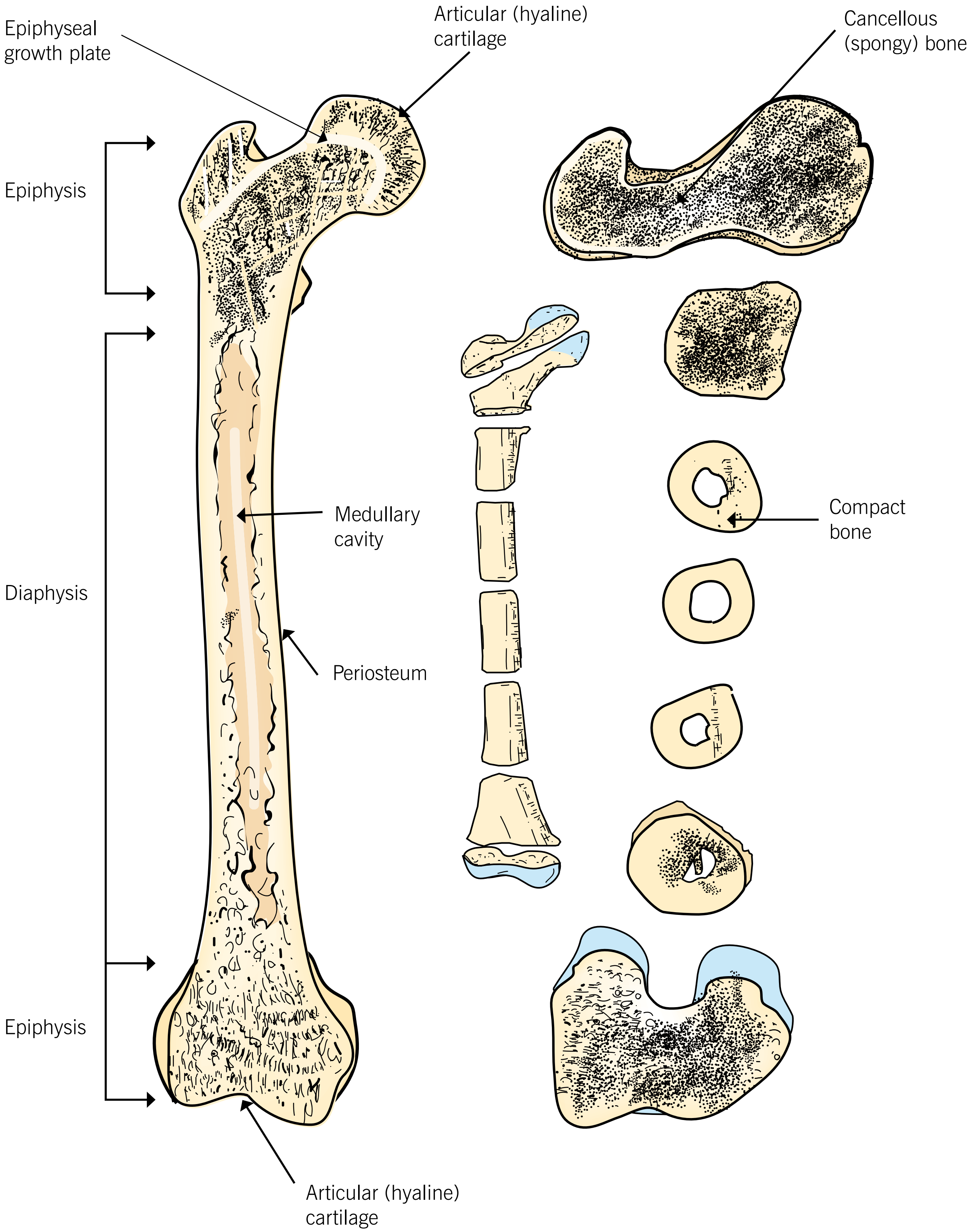
- flat bones – thin cancellous bones sandwiched between two compact layers affording protection or large areas for muscle attachment. Examples of these are the scapula, cranial bones, costals (ribs), sternum and ilium.

- irregular – form complex shapes and cannot be classified in the other groups. The vertebrae are considered to be irregular and contain varying proportions of compact and cancellous bone (reviewed in detail further on in this unit).

- sesamoid ('seed-like') – these bones develop within particular tendons at a site of friction or tension. They serve to reduce wear and tear in the tendon and increase leverage of muscle by moving the tendon away from the fulcrum. Examples include the patella (kneecap) and pisiform (carpal bone).

The anatomical features of a long bone

Although there are different classifications of bones, a closer analysis of a long bone is useful as it helps highlight many of the properties and functions of the skeletal system. The diagram below shows a cross section of a typical long bone (in this case the humerus).



- epiphysis (epiphyses) - the bone ends, which are mainly comprised of cancellous bone, and house much of the red marrow involved in red blood cell production. They are also one of the primary sites for bone growth, and during growth periods can be quite vulnerable to breakage.

- diaphysis - is the shaft portion of a long bone, and in comparison to the bone ends is predominantly compact bone (although the inside of the shaft is hollow). The principle role of the diaphysis is support.

- epiphyseal plates - are part of the region connecting the diaphysis to the epiphysis. It is a layer of subdividing cartilaginous cells where growth in length of the diaphysis occurs. Multiplying cartilaginous cells are arranged like columns of coins (Tortora and Grabowski, 1996) which move towards the diaphysis, becoming more calcified as they go. Osteoblasts will eventually complete the process of bone formation.

  When adults finish growing the plates will harden and ‘close’, no further growth will take place. If the plates are damaged before growth has finished, then this may result in a shorter bone. Wilmore and Costill (2004) note however, that little evidence exists that exercise has any affect on bone length in children. Instead it is more likely to lead to broader stronger bones (provided it is accompanied with appropriate diet).

- periosteum – this forms a tough fibrous membrane which coats the bone. It contains nerves, blood vessels and bone producing cells. Its inner surface provides the materials for repair and facilitates growth in the diameter of the bone. It also plays a fundamental role in movement by providing the point of attachment for tendons.

- medullary cavity – is a space which runs down through the centre of the diaphysis. This contains fatty, yellow marrow which is predominantly composed of adipose tissue, and serves as a useful energy reserve.

- articular (hyaline) cartilage – the ends of articulating bones are covered with articular or hyaline cartilage. It is a hard, white shiny tissue which, along with synovial fluid, helps reduce friction in freely moveable (synovial joints). It is fundamental for smooth joint action.

The anatomy of the skeleton

It is noted in the previous section that the bones of the skeleton can be classified according to their individual shapes and characteristics. Yet in order to function effectively, they must all be integrated in to one complete and coordinated system. Having said this, this system is often described in two parts; the axial skeleton and the appendicular (meaning 'to hang') skeleton.

Types of joint (articulations)

A joint is defined as the meeting point of two or more bones. The nature of these joints determines both the stability of the skeletal system and the potential for movement (Lee, 2001; Tortora and Grabowski, 1996). Although there are many joints, they are traditionally categorised into three different types: fibrous, cartilaginous and synovial.

- fibrous (immovable) joints - these represent some of the most rigid of the joints, such as the cranial joints. The cranial bones interlock with one another and are bound together with fibrous connective tissue. They possess high levels of stability but lack the ability for movement.

Fibrous joint – skull bones

- cartilaginous (slightly movable) joints - in these types of joint there is some limited potential for movement. Articulating bones are connected by fibrocartilage (see below). Examples include, the pubis symphysis and between the vertebral bodies. In contrast to the fibrous joints described above, they provide moderate stability and some limited movement.

Cartilaginous joint - spine

- synovial (freely movable) joints - these joints allow the 'large' movements we associate with exercise, consequently they will be discussed in more detail. These come in a variety of different configurations which allow different types of movement. They do however, share common characteristics which will be discussed first.

Synovial joint-shoulder

The anatomy of a synovial joint

Unlike the other forms of joint, the synovial joint has no connective tissue joining the articulating surfaces. Instead there is a joint space and the ends of the bones are covered with a form of cartilage (hyaline cartilage) which serves to reduce the friction between the moving surfaces.

Bony surfaces are held together by a fibrous articular capsule (joint capsule), which is flexible enough to allow plenty of movement but tough enough to support the joint where necessary. Sections of the joint capsule may thicken and form ligaments which provide additional support to the joint (Prentice, 1988). On the inner surface of the articular capsule is a synovial membrane which secretes a lubricant called synovial fluid. Synovial fluid has the consistency of uncooked egg white and is more viscous (thick) when the joint is inactive - fluidity increases as activity increases (Tortora and Grabowski, 1996). Synovial fluid serves to help lubricate the joint surfaces and provides nutrients to the articular cartilage, which has a poor blood supply.

Types of synovial joints

Although synovial joints share the same basic features, their structure and consequently the type of movements they allow, show considerable variation. Broadly speaking, these variations can be classified in to six categories; ball and socket, hinge, pivot, gliding, saddle and ellipsoid:

- ball and socket joint - a ball and socket joint allows for movement in almost any direction. They are found in the hips and shoulders.

Synovial ball and socket joint

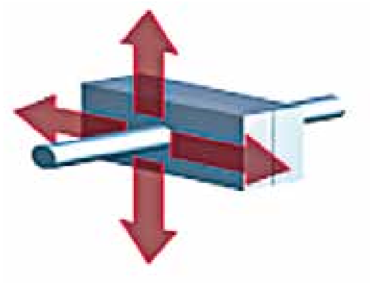
- hinge joint - like the hinges of a door, this type of synovial joint is a relatively simple structure. It primarily allows either flexion or extension movements (e.g. elbow joint).

Synovial hinge joint

- pivot joint - this form of joint allows rotation around an axis. In the neck, the top two cervical vertebrae (the atlas and the axis) form a pivot joint allowing rotational movements of the head. In the forearm, the radius forms a pivot joint with the ulna, causing it to 'radiate' around the ulna and allowing supination and pronation of the forearm.

Synovial pivot joint

- gliding joint – in this type of joint the articulating surfaces are typically flat, thus the joint action is a relatively simple sliding movement. Ligaments generally restrict movement to forwards, backward and side-to-side movements (Tortora and Grabowski, 1996). Examples of this kind of joint would be the patella and the femur (patellofemoral), between the carpals and tarsals and the acromion process and clavicle (acromioclavicular).

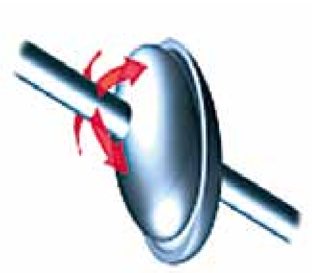


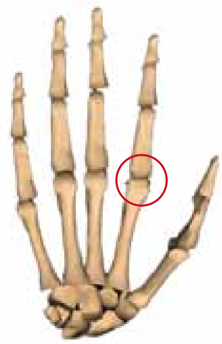
Synovial gliding joint

- saddle joint – this form of joint resembles one upturned saddle resting on another. It allows movement back and forth and up and down, but does not allow for rotation like a ball and socket joint. The articulation between the base of the metacarpal of the thumb and the trapezium (one of the carpals) is an example of a saddle joint (carpometacarpal).

Synovial saddle joint

- ellipsoid joint – these joints share similarities with the ball and socket joint in that a rounded bone fits into a rounded cavity. The shape is however, more oval in nature and consequently, movements tend to be restricted to side-to-side and back and forth. The wrist joint between the radius and the carpals (radiocarpal) and metacarpals and phalanges (metacarpophalangeal) are examples of this kind of joint. It is sometimes referred to as a condyloid joint.





Synovial ellipsoid joint

The vertebral column

By virtue of its complexity and the important role vertebral alignment plays in exercise, the vertebral column is worthy of a more detailed examination.

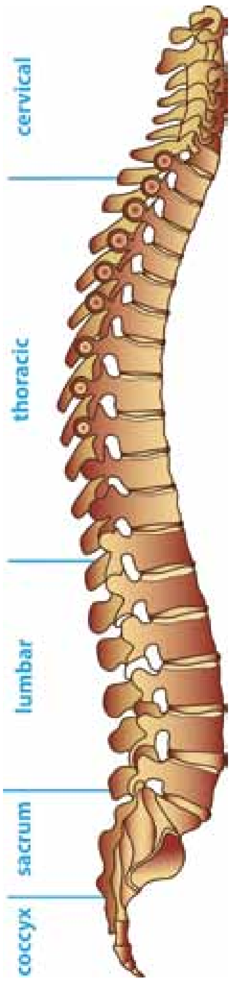
The vertebral column consists of a series of individual vertebra that are arranged to form a strong and flexible rod, which provides the body with central support and facilitates movement (Tortora and Graboski, 1996). It also offers protection for the spinal cord and provides the means by which nerves are distributed throughout the body.

The vertebral column usually consists of 33 individual vertebrae spread across five distinct sections:

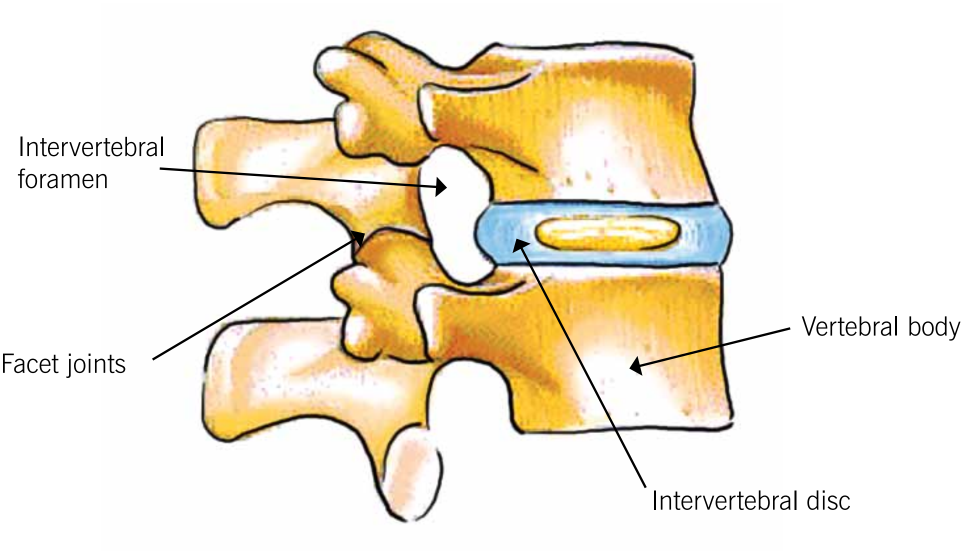
- the neck or cervical region is made up of 7 vertebrae
- the thoracic or chest section has 12 vertebrae
- the lumbar has 5 vertebrae
- the sacrum has 5 vertebrae
- the coccyx has 4 vertebrae

The fused vertebra in the sacrum and coccyx are often counted as one giving rise to 26 vertebrae. Interestingly, individual variation in the numbers of vertebra seems to be quite common, it being noted that individuals may possess extra vertebra in some regions and fewer in others. The cervical region appears to show the least variability (Gray, 2003; Bergman, Afifi and Miyauchi, 2004).

The anatomy of a vertebra and vertebral disc



Before considering the different regions of the spine in more detail, it is important to examine an individual vertebra more closely. Whilst differing considerably between regions, the vertebrae share the same basic anatomical features.



Structure of a vertebral disc

The diagram above shows a typical vertebra. To the anterior (the front) is the main vertebral body, which is a cylindrical bony disc. This provides the surface for the intervertebral discs to attach to and these form the main cartilaginous joints of the spine. To the posterior (the back) are a series of bony projections (processes) which interlink with adjacent vertebra to form synovial facet joints. A series of openings or foramen punctuate the vertebra, these allow nerves and blood vessels to pass though and out of the vertebral column.

The intervertebral discs are sandwiched between the bodies of neighbouring vertebrae. They are composed of a fibrocartilage shell, that surrounds a softer gel – like core, which is crudely described by McGill (2002) as looking and feeling '… like heavy phlegm.' Their primary function is shock absorption, however, they are vulnerable to injury if the back is excessively loaded with poor alignment (discussed below) or if the back is held in a chronically poor posture (i.e. sitting at a desk with a rounded back) (McGill, 2002).

Anatomical and functional variations in the vertebral column

Whilst it is noted above that the vertebra have the same basic features, there are considerable anatomical and functional variations between the different regions of the spine. These are summarised in the table below:

Region	No. of vertebrae	Key features
Cervical	7	• the smallest of the vertebrae • facilitates movement of the head • contains larger and a greater number of openings (foramen) to accommodate nerves and blood vessels
Thoracic	12	• forms joints with the costal bones • capable of relatively more rotation than the lumbar vertebrae
Lumbar	5	• the largest vertebrae, to support greater loads • capable of relatively more flexion, extension and lateral flexion than the thoracic vertebrae
Sacrum	5	• forms a joint with the pelvis • usually fully fused by the age of 30 years
Coccyx	4	• the lowest section of the vertebral column • usually fused by the age of 30

A comparison of the different regions of the vertebral column

Vertebral alignment and posture

It was suggested earlier that a spine that is held in a 'poor' position is more likely to suffer injury. In order to understand what constitutes a 'good alignment' it is necessary to examine the normal curvature of the spine.

The optimal arrangement of curves is referred to as a neutral spine and represents a position where the vertebrae and associated structures are under the least load. The adult human spine has three major curvatures (excluding the sacrococcygeal), these are:

- a posterior cervical curvature – a posterior concavity of the cervical spine
- an anterior thoracic curvature – a posterior convexity of the thoracic spine
- a posterior lumbar curvature – a posterior concavity of the lumbar spine

Identifying optimum posture can be tricky as clothing and other parts of the anatomy may obscure the vertebral column. Chek (2004) suggests that, if a line can be dropped vertically from the ear through the middle of the shoulder and hip to a point just in front of the ankle, then posture is probably ideal.

Functional kinesiology

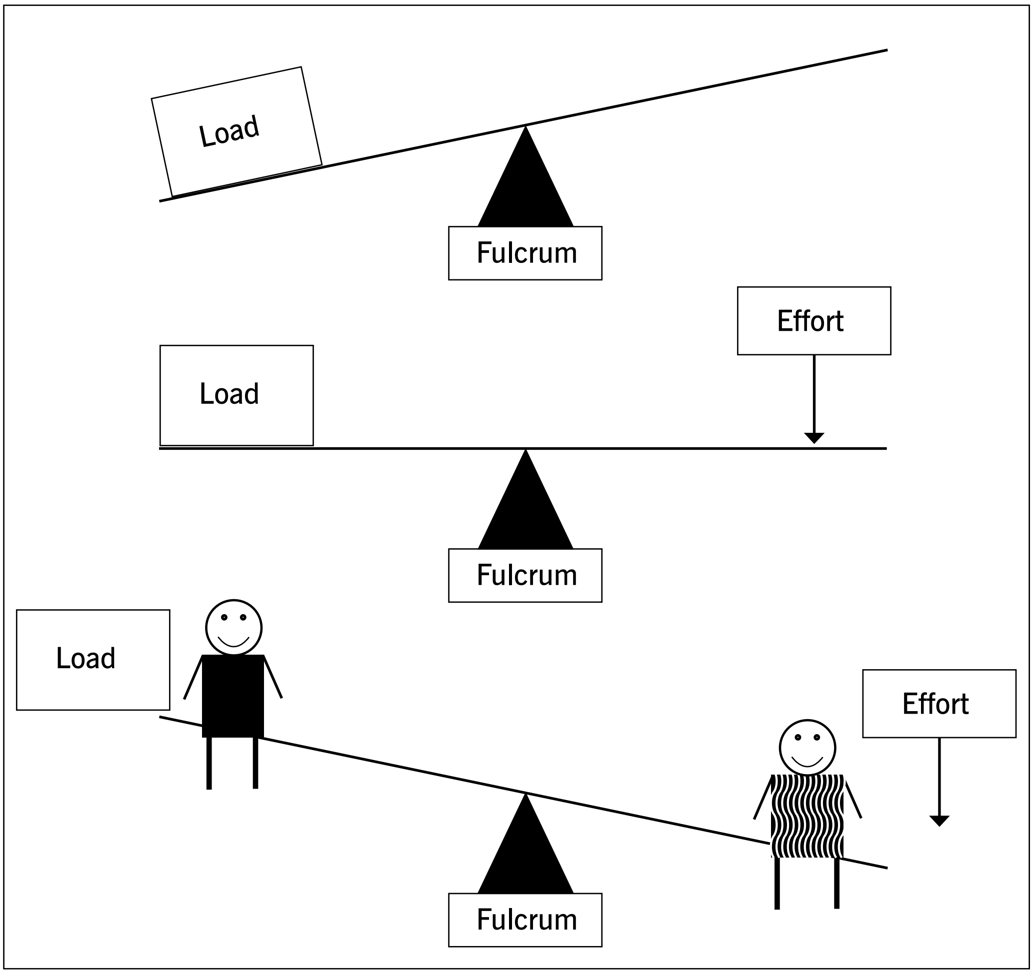
Kinesiology ('the study of movement')

An understanding of movement allows better judgments regarding choice of exercises and their execution. The following chapter explores some of the ways in which human anatomy and movement can be described in terms of levers, planes and axes.

Levers

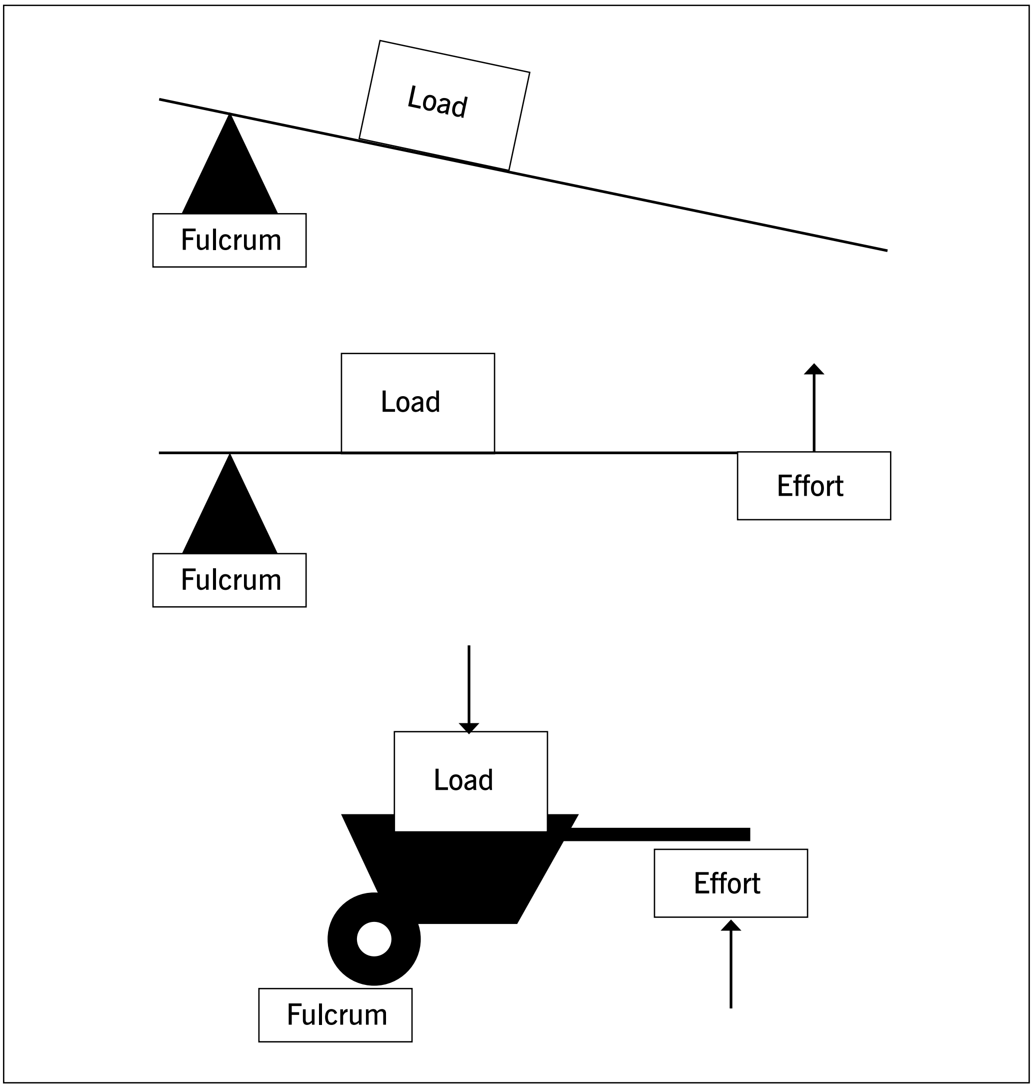
Humans move or pick up objects via a basic system of levers. A lever is a simple machine consisting of a rigid rod that moves or pivots around a fixed point (fulcrum). By varying the position of the fulcrum, the load or the effort; different combinations of speed, range of movement and force can be generated. There are three basic forms of lever.

- 1st class levers: the best example of this kind of lever is a seesaw. The fulcrum is located between the effort and the load. By moving the fulcrum closer to, or further away from the load; speed, range of movement and force generated will vary. In spite of its simplicity, this form of lever is relatively scarce in the body. Examples include the triceps extending the forearm; gastrocnemius and soleus plantarflexing the foot when it is off the ground.



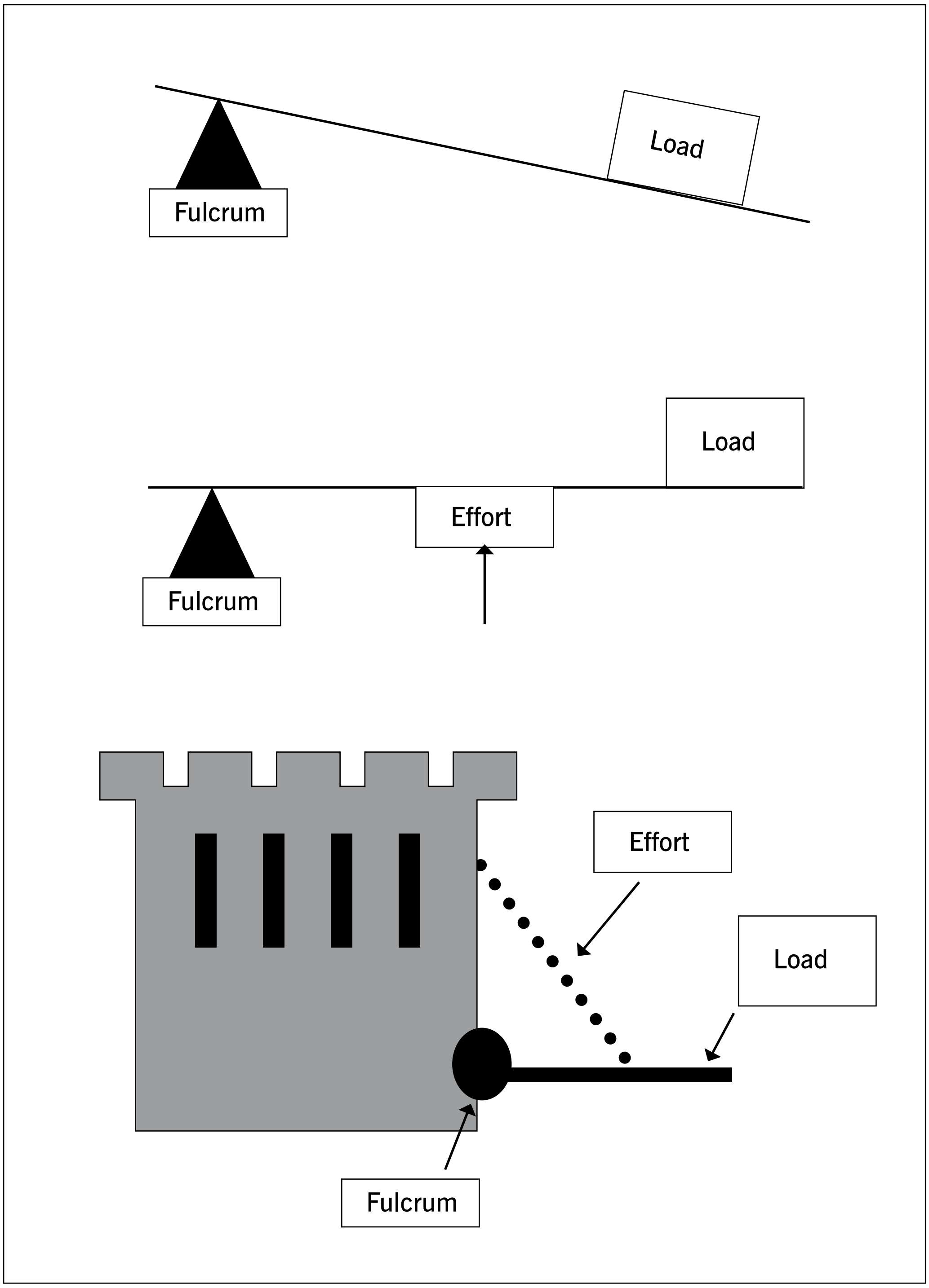
The seesaw: a 1st class lever

- 2nd class levers: the best example of this type of lever is a wheel barrow. The fulcrum and the effort are at opposite ends with load placed in between. This arrangement produces plenty of force, but like 1st class levers there are relatively few examples in the body.



The wheel barrow: a 2nd class lever

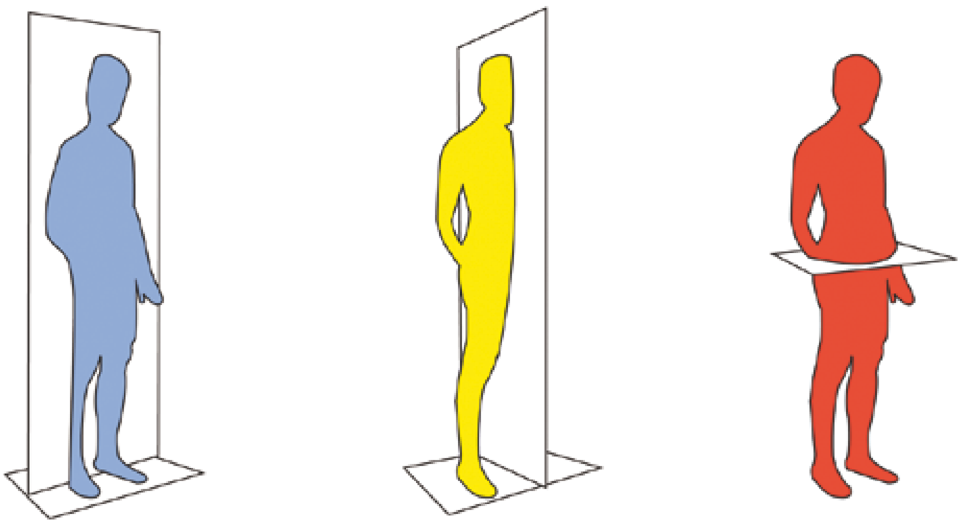
- 3rd class levers: the most common form of lever in the body. The fulcrum and the load are at opposite ends with the effort placed in between. This arrangement is similar to the action of a drawer bridge and generally produces less force than the other forms of lever, but provides a much greater range of movement and speed.



The drawer bridge: a 3rd class lever

Anatomical planes

Planes are imaginary flat surfaces along which movement can occur or that represent anatomical cross-sections. There are three basic planes; frontal (coronal), sagittal and transverse.



Frontal plane *Sagittal plane* *Transverse plane*

- frontal plane:
  a vertical plane that divides the body into anterior and posterior parts

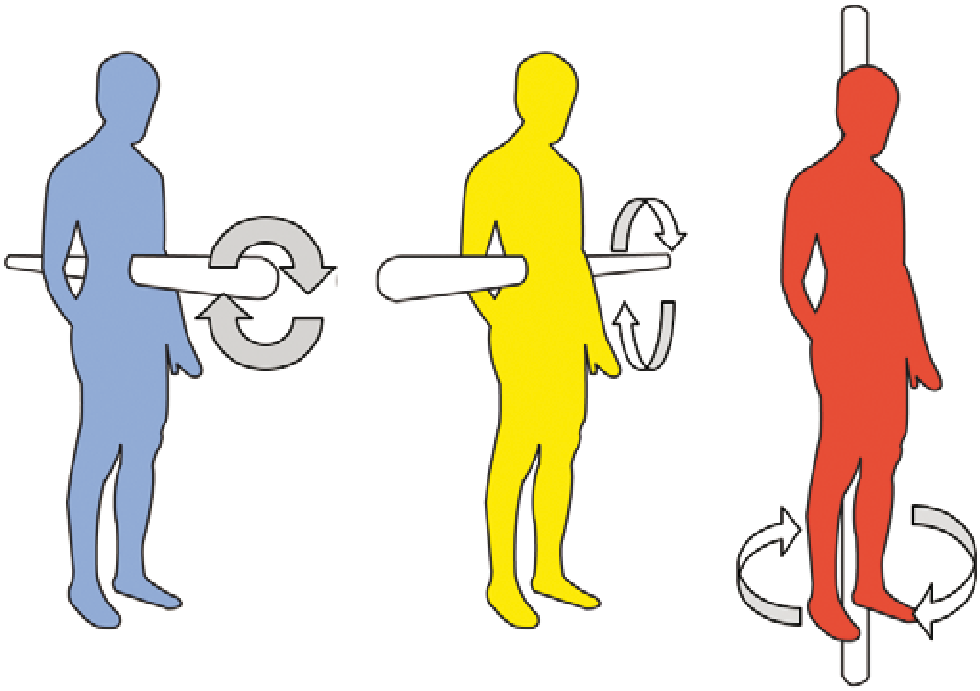
- sagittal plane:
  a vertical plane that divides the body into left and right parts

- transverse plane:
  a horizontal cross-section through the body separating the upper body from the lower body

It is important to point out that human movement occurs simultaneously in multiple planes.

Axes of movement

An axis is a line that passes through a plane, about which movement (rotation) occurs.



Anterior-posterior axis *Medial-lateral axis* *Longitudinal axis*

- **medial-lateral axis:**
  passes through the sagittal plane: rotation would occur in the sagittal plane

- **anterior-posterior axis:**
  passes through the frontal plane: rotation would occur in the frontal plane

- **longitudinal axis:**
  passes through the transverse plane: rotation would occur in the transverse plane

The muscular system

Human movement is dependant upon the integrated activity of many different systems, however, the driving force behind this is the muscular system. This section will explore and discuss the microscopic structure of muscle which enables muscles to generate force.

Types of muscle tissue

Smooth muscle

Smooth muscle is the most widely distributed and it predominates in the internal tissues of the body, including the digestive, circulatory, urinary and reproductive systems. One of its major functions is to regulate the diameter of tubular structures, thus enabling the body to regulate blood flow and blood pressure, the passage of food down the digestive tract and even the amount of light entering the eye. Control of this form of muscle is involuntary and is exerted via the autonomic system.

Cardiac muscle (myocardium)

Cardiac muscle is found only in the heart, but like smooth muscle is also under involuntary control. The unique feature of cardiac muscle is that it possesses the capability of self excitation. In other words, it will continue to contract even if completely separated from the rest of the body (for a short time at least). The autonomic system exerts some control over cardiac muscle by both increasing or decreasing heart rate and the strength of contractions. This is examined more closely in the cardiovascular chapter.

Skeletal muscle

Skeletal muscles are attached from bone-to-bone across joints, and are the main focus of this chapter. Unlike cardiac and smooth muscle, skeletal muscle is predominantly under voluntary control via the somatic nervous system. Skeletal muscle has a number of functions such as:

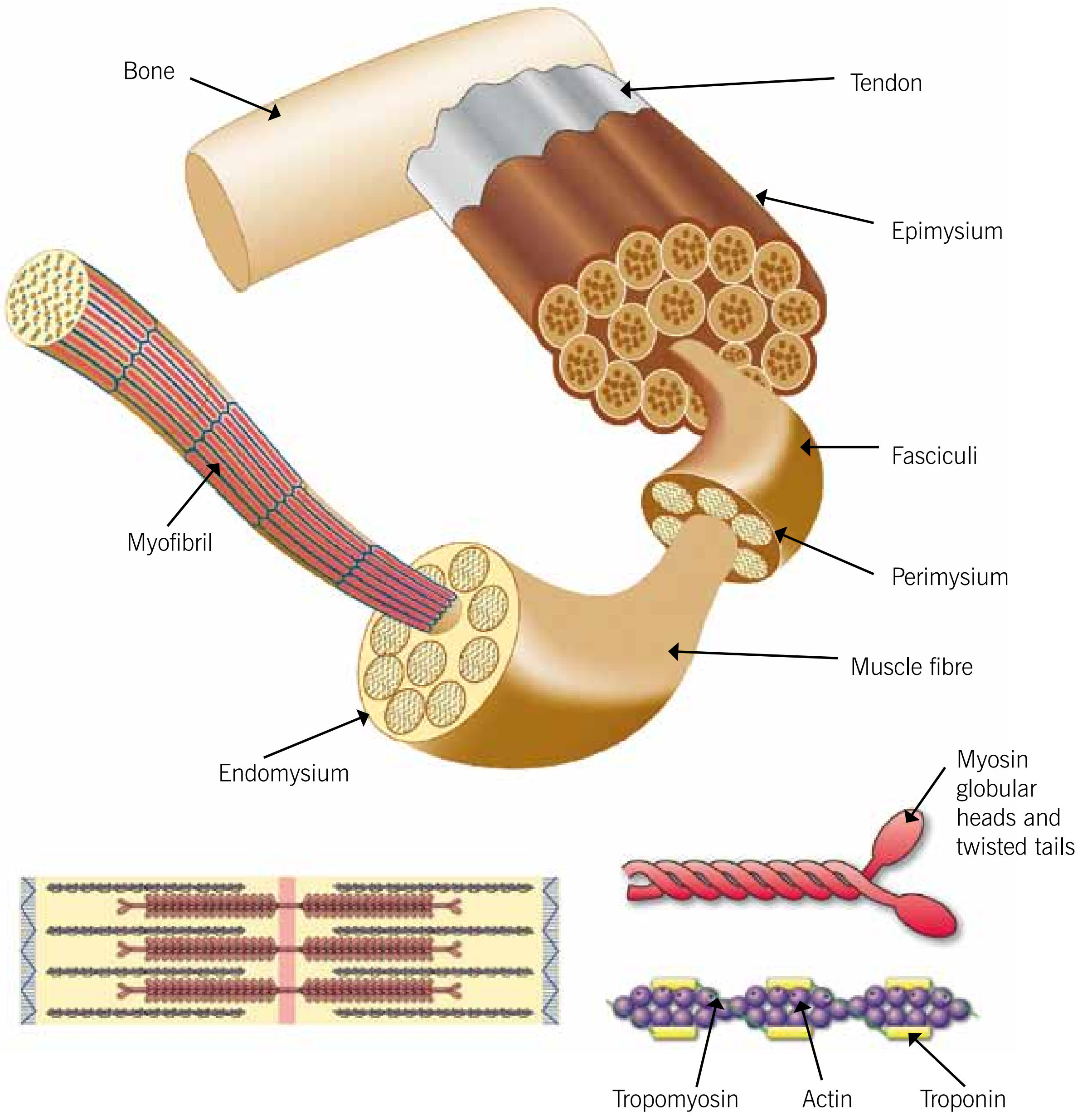
- producing movement
- stabilising body positions i.e. maintenance of posture
- facilitating the circulation of blood and lymphatic fluid
- generating heat

The anatomy of skeletal muscle

In order to understand how muscles generate force it is necessary to review the basic anatomy of a muscle. In simple terms, skeletal muscle is made up of a number of rod-like structures called muscle fibres, and these fibres run parallel along its length. Closer examination of muscle will reveal that each series of fibres are themselves constructed from smaller parallel fibres and so on.

Surrounding and protecting muscles are a series of collagen based membranes, the outer most of which covers the whole muscle and is called the epimysium (epi – meaning 'upon'). Within the epimysium are groups of muscle fibres formed into bundles called fascicles. Each fascicle has its own outer sheath called a perimysium (peri – meaning 'around'). Within each fascicle are bundles of muscle fibres each separated from the other by, yet another membrane called the endomysium (endo – meaning 'inside').

This connective tissue is continuous throughout the length of the muscle fibres and beyond, where it converges to form the tendons. These are strong, inelastic, strap-like structures that attach muscle to the periosteum (tough fibrous layer that coats the bones) e.g. Achilles tendon.



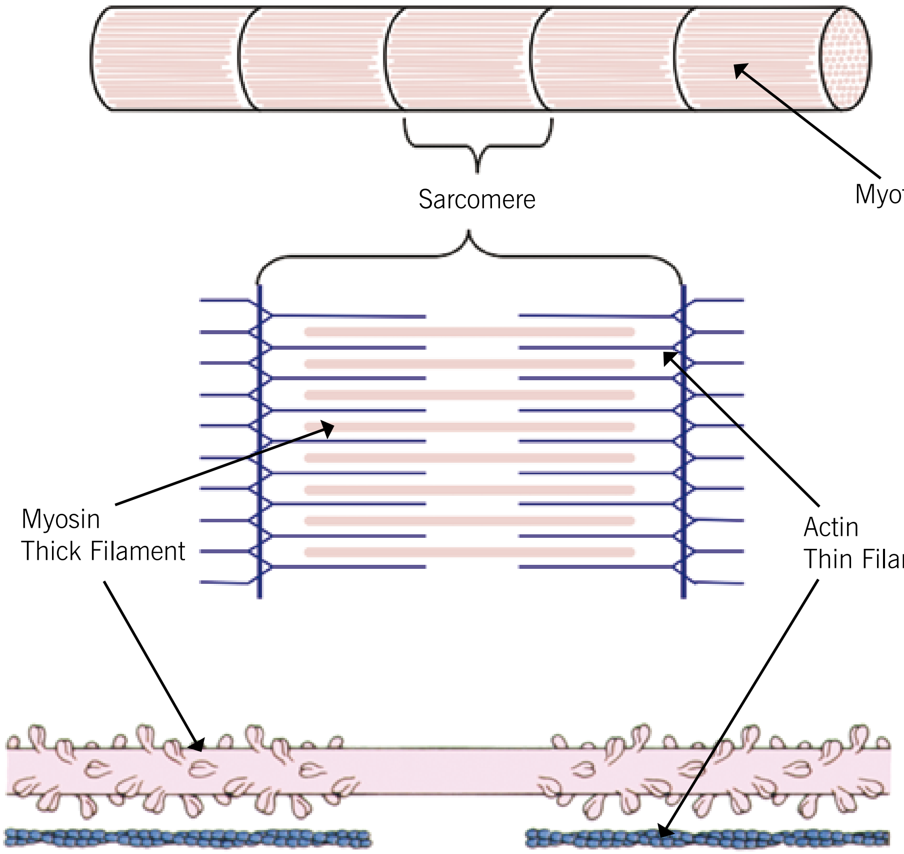
Basic structure of a muscle

Force generation

To explain how muscles generate force it is necessary to look even closer at the fine structure of muscle fibres. Below the endomysium are even smaller rows of fibres called myofibrils. Contained within these fibres are the structures which are responsible for force production.

Myosin and actin and the sliding filament mechanism

The 'business end' so to speak of force generation are two contractile proteins called myosin and actin, often referred to as thick and thin filaments respectively. These are arranged in a series of compartments called sarcomeres that run the length of the myofibril.



The basic functional unit of the muscle

Spiralling from the myosin filament is a series of 'hook like' projections referred to as myosin heads. During muscular contraction these heads attach themselves to the actin filament and rotate. The result of this is that the thinner actin filaments are drawn inwards dragging the ends of the sarcomeres together, this is referred to as the sliding filament mechanism.

Myosin and ATP: the power to drive the myosin head is provided by adenosine triphosphate (ATP – see energy systems section). The ATP molecule primes the myosin for activity by binding with the head. Energy from the ATP is almost immediately transferred to the head rather like a finger cocking a gun. When the conditions are right, the myosin head will bind with the actin and rotate.

Actin and calcium: although the myosin head may have been primed with energy from the ATP, it will be unable to bind with the actin without the presence of calcium. In a relaxed state, the myosin binding sites on the actin are blocked by a combination of other molecules (troponin and tropomyosin), that must be moved before myosin can be attached.

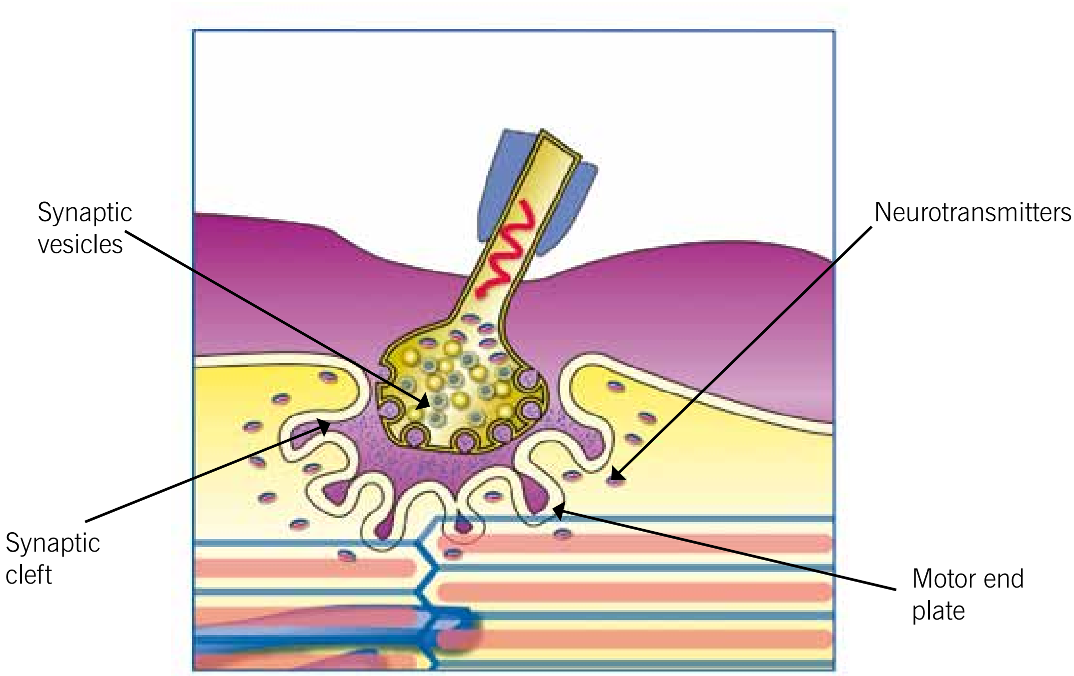
Surrounding the myofibrils is a network of tubes called the sarcoplasmic reticulum (SR) that act as calcium reservoirs. Stimulation of the sarcoplasmic reticulum (by an action potential) causes them to release their calcium into the fluid surrounding the myosin and actin (sarcoplasm). The calcium causes the blocking molecule to move away from the myosin binding site, thus allowing the 'primed' myosin head to bind with the actin and rotate.

Without the influx of calcium into the muscle fibre, the sliding filament mechanism could not take place. The question arises therefore, as to what triggers the sarcoplasmic reticulum to flood the myofibril with calcium. To understand this process, it is necessary to take a look at the point at which nervous impulses reach the muscle.

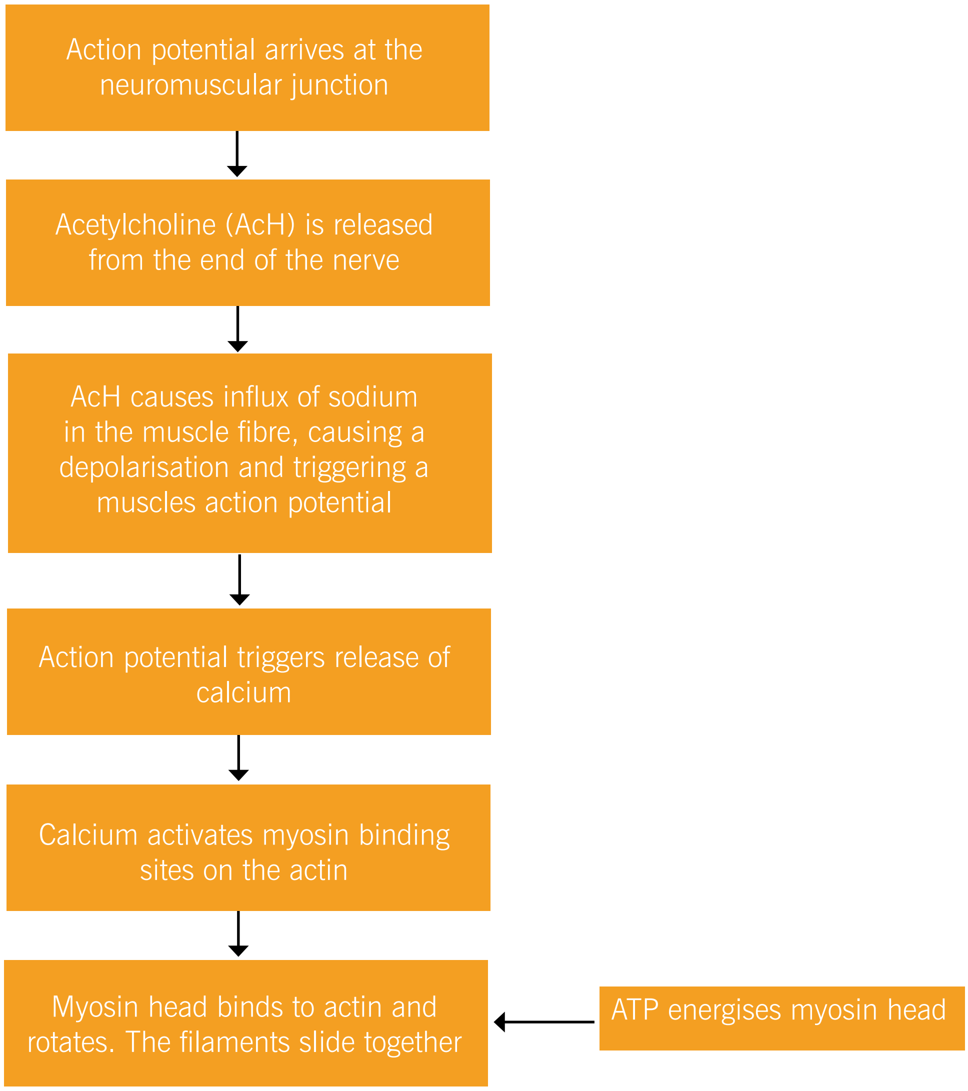
Action potentials

The stimulus for the release of calcium is the spread of electrical activity (the action potential) along the length of the muscles. In a resting state, muscle membranes have a negatively charged interior and a positively charged exterior. The difference between the two serves as a form of potential energy, rather like that stored in a battery (Tortora and Grabowski, 1996). This is achieved through a combination of a selective permeability of the cell membrane and the presence of sodium pumps that actively remove positively charged sodium from the cell.

The arrival of an action potential at the neuromuscular junction (where the nerve meets the muscle) causes the release of a neurotransmitter (acetylcholine), which in turn causes sodium to rush through the muscle membrane. As a result, there is a reversal of electrical activity (depolarisation), which if great enough, will cascade along the muscle fibre as an action potential, thereby triggering calcium release and beginning the sliding filament mechanism.



Neuromuscular junction



Initiation of a muscle action

Control of muscular activity

Having explored the fundamentals of muscular contraction, we now have a better understanding of how they generate force. However, a number of questions remain regarding the mechanisms through which muscle activity is controlled. The following section will therefore, take a closer look at muscular control systems.

Motor units and the 'all or nothing' law

Muscles are divided in to motor units; a single motor unit consists of one motor neuron (nerve) and the muscle fibres it innervates. As was discussed earlier, if the stimulus is strong enough to trigger an action potential, then it will spread through the whole length of the muscle fibre. More specifically, it will spread through all the muscle fibres supplied by a single nerve. Conversely, if the stimulus is not strong enough, then there will be no action potential and no muscle contraction. Motor units cannot, therefore, vary the amount of force they generate, they either contract maximally or not at all – hence the 'all or nothing' law.

Control of muscular force is achieved through a combination of adjusting the number of motor units recruited (i.e. the greater the number the greater the force) and also increasing the frequency of their discharge.

It is worth noting that coordinating motor unit activity is fundamental to optimising force generation and therefore, improving exercise performance (McArdle et al., 2001).

Muscle proprioceptors

The muscles have two small neural sensors that help to provide feedback and respond to changes within the muscle itself. The first is called the muscle spindle and it is located deep within the muscle fibres. The spindle is a small sensory unit wrapped tightly around the individual muscle fibres like a coiled spring. When the muscle changes length the 'coils' of the muscle spindle are either pulled apart or pushed together depending on whether the muscle is lengthening or shortening. This change in muscular length and resulting change in the muscle spindle stimulates neural firing to the central nervous system at the spinal level. The net result of a lengthened muscle and muscle spindle is a stimulus to contract the same muscle. The degree of contraction that occurs will depend on the degree of change in muscle length and the rate at which the change in length occurs. As a general rule, the greater the range of motion and the faster the muscle lengthens the greater the resulting contraction will be. This process is often referred to as the stretch reflex.

The second proprioceptor that has an influence on the muscle is actually located in the tendon and as such is called the Golgi Tendon Organ (GTO). The tendon is inelastic and so the GTO cannot detect changes in muscle length. However, when a muscle contracts, it pulls on the tendon, creating tension within that tendon. The GTO is ideally located to measure the amount of tension created by a muscle. The GTO, when activated, sends a signal to the spine which brings about an inhibitory effect on the same muscle. This relaxation response brought about as a result of GTO firing is called the inverse stretch reflex.

The muscle spindles will be continually activated during human movement as the muscles will be changing lengths in conjunction with the movements being carried out. This is providing a constant stream of valuable information to the CNS about muscle length and where body parts are in space. The spindles also bring about muscular contraction that assists with the movements being performed. The GTO responds just after muscular contraction has engaged by inhibiting the muscular contraction to allow the opposite action to be performed. Therefore, muscle spindles and GTO's serve like the on and off switches for muscle activity during exercise and movement. It is also valuable to note that, when a muscle is causing its primary actions to occur the opposing muscles need to be switched off to allow that movement to take place. This inhibition of the opposing muscles is called reciprocal inhibition (RI). RI is a necessary part of normal movement. However, it can also play a part in creating muscular imbalance. A very tight muscle group will send a continuous RI signal to the opposing muscle which can lead to that muscle becoming inhibited in its function.

Exercise and training has been shown to increase the neural side of the muscular response with improvements in the stretch reflex and the net response from the inverse stretch reflex. Training modalities like plyometrics have been developed particularly to develop the stretch shortening cycle with effective results. Not only does the muscle learn to develop more force through this type of training, but timing and co-ordination of movement at speed also improves as the muscle spindles in supporting muscle tissue are also trained to respond better.

Effects of exercise on muscle tissue type

Whilst it is acknowledged that exercise in general will have a positive impact on muscle tissue development, certain types of activity have been shown to influence different muscle fibre types. Simply put, muscles have three categories of muscle tissue, Type 1 or slow twitch, Type 2a and Type 2b or fast twitch. Science is continuing to expand this area of knowledge and other types of muscle tissue have been determined based on function and response.

The Type 1 muscle fibres have been found to be the most aerobic in nature with greater blood supply and more mitochondria and as a result respond well to aerobic, low to moderate intensity training. The Type 2b muscle fibres are very anaerobic in nature with a reduced blood supply in comparison to the Type 1 and much fewer mitochondria. Type 2 fibres respond well to high intensity exercise with higher force and power outputs. The Type 2a fibres have all the characteristics that one would find in other fast twitch fibre types, but with the added ability to adapt a little more and take on some of the properties of the Type 1 fibre. Type 2a fibres will respond to varying levels of exercise intensity in the direction of the stimulus applied.

Muscle fatigue, soreness and oxygen debt

At some point, everybody experiences muscular fatigue, which is simply a decline in the ability of the muscle to produce force. As should now be appreciated, there are many stages to a muscular contraction, and thus the causes of muscle fatigue may vary. In fact, McArdle et al. (2001), note that fatigue may result from an interruption of any of '… the chain of events between the CNS and the muscle fibre.'

With respect to the nervous system, diminishing levels of neurotransmitter may reduce the volume of action potentials reaching the muscle fibres. Also more complex neural interactions associated with perceptions of pain and discomfort may serve to diminish performance. Within the muscle fibres themselves, fatigue can arise from a number of sources. Depletion of glycogen stores will limit the rate at which ATP can be synthesised, whereas insufficient oxygen will lead to changes in the internal chemistry which directly interrupts the sliding filament mechanism.

The cause of fatigue will very much be dependent on the mode of exercise being undertaken.

Delayed onset muscle soreness (DOMS): in contrast to pain or discomfort felt during exercise, delayed-onset muscle soreness (DOMS) typically occurs 24 – 72 hours following a fairly heavy bout of exercise activity. The precise mechanisms behind DOMS are still poorly understood, some suggest the soreness relates to structural damage, whilst others suggest that they are an inflammatory response. Wilmore and Costill (2004), indicate that both mechanisms may be involved.

Although the processes behind DOMS remain unclear, the causes seem to be universally agreed upon; DOMS is associated with intense eccentric muscular activity (Jones and Round, 1991; McArdle et al, 2001; Wilmore and Costill 2004). Although Prentice (1998), also suggests that unfamiliarity with an exercise may contribute to DOMS.

With respect to minimising DOMS, Wilmore and Costill (2004), highlight a number of approaches. The first would involve minimising eccentric muscle activity during the early stages of training, yet this may be difficult to implement, particularly in sports. The second involves starting a progressive training programme at a very low intensity and introducing overload fairly gently. It is reasonable to argue that this is probably the best approach for a new client. The final approach is not for the faint hearted and involves beginning training at a high intensity. Although DOMS will initially be high, subsequent exercise will produce less and less muscle soreness.

Types of muscle action

Consider a bicep curl or a squat, think of the muscles used to perform the task - are the muscles used to lift the weight the same as those used to lower it back down again? The answer to this question should of course be 'yes.' However, the activities of the muscles concerned are fundamentally different. When lifting the weight the muscle will be shortening, when lowering the weight the muscle will be lengthening. Pause the activity in the middle, and the muscle stays the same length. All the time, however, be aware that the muscle is working.

In order to help distinguish between the different types of muscular activity a number of terms are used:

- isotonic (same tone) - used to describe muscle actions involving movement, i.e. concentric and eccentric
- concentric - muscle generates force whilst shortening
- eccentric - muscle generates force whilst lengthening
- isometric - muscle generates force and remains the same length
- isokinetic (same speed) - muscle actions involving movement at a constant speed

Thus during the lifting action of a bicep curl, the bicep brachii would be working concentrically. If at any point, the weight were held still, then this would represent an isometric action. Finally, as the weight was lowered (in a controlled manner) the biceps would be lengthening and thus working eccentrically.

Roles of muscles

Ultimately, efficient human movement is dependent on the coordinated activity of whole groups of muscles and will involve varying combinations of different muscle actions. In an attempt to distinguish between the diverse roles of muscle during movement, muscles can be placed into the following categories:

- agonist/prime mover: the muscle(s) that causes a desired action. e. g. the bicep brachii during a bicep curl or the quadriceps during a leg extension
- antagonist: the opposing muscle(s) to the agonist e.g. the triceps during a bicep curl or the hamstrings during a leg extension
- synergist: the muscle(s) that assist or modify the movement of the prime mover e.g. during hip extension the hamstrings act as synergists for the gluteus maximus
- fixators: the muscle(s) that stabilises the part of the body that remains fixed e.g. shoulder girdle muscles stabilise the scapula to allow efficient movement at the shoulder joint

<table>
<tr><th colspan="2">Level 2 : Black
Level 3 : Orange</th><th>Location</th><th>Origin</th><th>Insertion</th><th>Primary concentric actions</th></tr>
<tr><td colspan="2">Deltoids</td><td>Shoulder</td><td>Clavicle and scapula</td><td>Humerus</td><td>Abduction, flexion and extension of shoulder</td></tr>
<tr><td rowspan="4">Rotator cuff</td><td>Teres minor</td><td rowspan="4">Shoulder</td><td>Lateral border of scapula</td><td>Greater tuberosity of humerus</td><td>Abduction, lateral rotation and stabilisation of shoulder joint</td></tr>
<tr><td>Supraspinatus</td><td>Superior to spine of scapula</td><td>Greater tuberosity of humerus (superior)</td><td>Abduction and stabilisation of shoulder joint</td></tr>
<tr><td>Infraspinatus</td><td>Posterior surface below spine of scapula</td><td>Greater tuberosity of humerus (posterior)</td><td>Abduction, horizontal extension, lateral rotation and stabilisation of shoulder joint</td></tr>
<tr><td>Subscapularis</td><td>Anterior surface of scapula</td><td>Lesser tuberosity of humerus</td><td>Medial rotation, adduction, extension and stabilisation of shoulder joint</td></tr>
<tr><td colspan="2">Teres major</td><td>Shoulder</td><td>Inferior angle of scapula</td><td>Medial lip of bicipital groove of upper humerus</td><td>Extension, adduction and medial rotation of shoulder</td></tr>
<tr><td colspan="2">Levator scapulae</td><td>Upper back and neck</td><td>Transverse processes of C1-C4</td><td>Superior angle of scapula</td><td>Elevation of shoulder girdle and lateral flexion of neck</td></tr>
<tr><td colspan="2">Biceps brachii</td><td>Front of upper arm</td><td>Scapula</td><td>Radius</td><td>Flexion of elbow, supination of forearm and flexion of shoulder</td></tr>
<tr><td colspan="2">Triceps brachii</td><td>Back of upper arm</td><td>Humerus and scapula</td><td>Ulna</td><td>Extension of elbow and extension of shoulder</td></tr>
<tr><td colspan="2">Latissimus dorsi</td><td>Sides of the back</td><td>Lower thoracic vertebrae, lumbar vertebrae, ilium</td><td>Humerus</td><td>Adduction, extension and medial rotation of shoulder</td></tr>
<tr><td colspan="2">Trapezius</td><td>Upper back</td><td>Base of skull, cervical and thoracic vertebrae</td><td>Clavicle and scapula</td><td>Elevation, retraction and depression of shoulder girdle</td></tr>
</table>

Level 2 : Black Level 3 : Orange		Location	Origin	Insertion	Primary concentric actions
Rhomboids	Major	Mid back	Spinous processes of T2-T5	Medial border and inferior angle of scapula	Retraction and elevation of scapula
	Minor	Mid back	Spinous processes of C7-T1	Medial border of scapula	Retraction and elevation of scapula
Pectoralis major		Chest	Clavicle and sternum	Humerus	Horizontal flexion, adduction and medial rotation of the shoulder
Pectoralis minor		Chest	Anterior surface of 3rd-5th rib	Coracoid process of scapula	Depression and protraction of scapula
Serratus anterior		Side of the torso	Surface of upper 8 or 9 ribs	Anterior surface of medial border of scapula	Protraction of scapula
Erector spinae		Either side of spine	Sacrum, ilium, ribs, vertebrae	Ribs, vertebrae, occipital bone	Extension and lateral flexion of spine
Iliocostalis (3 erector spinae muscles)		Either side of spine	Sacrum, iliac crest and spinous processes of lumbar and lower thoracic vertebrae	Ribs and transverse processes of cervical vertebrae	Lateral flexion of the neck and extension of the vertebral column
Longissimus (3 erector spinae muscles)		Either side of spine	Transverse processes of the lumbar and thoracic vertebrae	Ribs and transverse processes of the thoracic and cervical vertebrae and mastoid process	Lateral flexion of the neck and extension of the vertebral column
Spinalis (2 erector spinae muscles)		Either side of spine	Spinous processes of lumbar and thoracic vertebrae	Spinous processes of the upper thoracic and cervical vertebrae	Lateral flexion of the neck and extension of the vertebral column
Multifidus		Either side of spine	Posterior superior iliac spine (PSIS), transverse processes of lumbar, thoracic and C4-C7 vertebrae	Spinous processes of 2nd-4th vertebrae above each origin	Extension and rotation of vertebral column

Level 2 : Black Level 3 : Orange		Location	Origin	Insertion	Primary concentric actions
Quadratus lumborum		Lower back	Iliac crest	12th rib and transverse processes of L1-L4	Lateral flexion and extension of spine
Rectus abdominis		Along the centre of the abdomen	Pubis	Sternum	Flexion of spine, lateral flexion of spine
Internal obliques		Sides of the abdomen	Ribs, ilium	Ilium, pubis, ribs, linea alba	Rotation and lateral flexion of spine
External obliques		Sides of the abdomen	Ribs	Ilium, pubis	Rotation and lateral flexion of spine
Transversus abdominis		Abdomen	Iliac crest and lumbar fascia	Pubis and linea alba	Support of internal organs and forced expiration
Diaphragm		Beneath rib cage	Sternum, costal cartilages and lumbar vertebrae	Central tendon of diaphragm	Depresses and aids in expiration
Intercostals		Between ribs	Ribs and costal cartilages	Superior border of next rib below	Elevates ribs and aids in expiration
Hip flexors	Iliacus	Through the pelvis and onto the femur	Iliac fossa	Lesser trochanter of femur	Flexion and lateral rotation of hip
	Psoas major		Transverse processes of T12 –L5	Lesser trochanter of femur	Flexes and laterally rotates hip
Gluteus maximus		Bottom	Ilium	Femur	Extension and external rotation of the hip
Abductors	Gluteus medius	Outside of upper thigh	Lateral and posterior ilium	Posterior and lateral surface of greater trochanter of femur	Abduction and medial rotation of hip
	Gluteus minimus		Lateral ilium	Anterior surface of greater trochanter of femur	Abduction and medial rotation of hip
Piriformis		Posterior hip	Anterior sacrum	Upper surface of greater trochanter of femur	Abduction and lateral rotation of hip
Tensor fascia latae		Outer thigh	Anterior iliac crest	Lateral upper tibia via iliotibial band (ITB)	Flexion and abduction of hip
Adductors	Magnus	Inner thigh	Pubis, ischium	Femur	Adduction of hip
	Longus				
	Brevis				
Pectineus		Inner thigh	Anterior pubis	Lesser trochanter and upper femur	Adduction and flexion of hip
Gracilis		Inner thigh	Ischio-pubic ramus	Medial tibia below condyle	Adduction of hip and flexion of knee

Level 2 : Black Level 3 : Orange		Location	Origin	Insertion	Primary concentric actions
Sartorius		Front and inner thigh	Anterior superior iliac spine (ASIS)	Medial condyle of tibia	Flexion, abduction and lateral rotation of hip, flexion and medial rotation of knee
Quadriceps	Rectus femoris	Front of thigh	Anterior inferior iliac spine (AIIS)	Tibial tuberosity via patella	Flexion of hip and extension of knee
	Vastus lateralis		Lateral femur and greater trochanter	Tibial tuberosity via patella	Extension of knee
	Vastus intermedius		Medial femur	Tibial tuberosity via patella	Extension of knee
	Vastus medialis		Anterior femur	Tibial tuberosity via patella	Extension of knee, especially last 20° motion
Hamstrings	Biceps femoris	Back of thigh	Ischial tuberosity and posterior femur	Head of fibula and lateral condyle of tibia	Extension of hip and flexion of knee
	Semitendinosus		Ischial tuberosity	Medial condyle of tibia	Extension of hip and flexion of knee
	Semimembranosus		Ischial tuberosity	Anterior medial surface of tibia	Extension of hip and flexion of knee
Gastrocnemius		Calf	Femur	Calcaneus (heel bone)	Plantarflexion of ankle, flexion of knee
Soleus		Calf, beneath gastrocnemius	Tibia	Calcaneus (heel bone)	Plantarflexion of ankle
Tibialis anterior		Front of lower limb (shin)	Tibia	Metatarsal and tarsal	Dorsiflexion and inversion of ankle

The nervous and endocrine systems

The nervous and endocrine systems are the means by which the body maintains homeostasis (a stable internal environment). The nervous system does so via a complex web of nerves, whereas the endocrine system supports homeostasis through a series of glands and hormones (chemical messengers).

As exercise activity represents one of the biggest challenges to the internal environment of the body, it is important to understand how these two systems help regulate this environment. Although clearly distinct from one another, the two systems work closely together, one often triggering a response in the other. However, for the purposes of clarity each will be addressed separately here.

Role of the nervous system

At its simplest level the nervous system is a communication network, which has three basic elements; sensation, analysis and response (Tortora and Grabowski, 1996):

- sensation - there are a vast array of sensors spread throughout the body which continually gather information about both the internal environment (e.g. blood CO2 levels) and the external environment (e.g. air temperature)
- analysis - sensory input represents massive amounts of information, thus the second role of the nervous system is to analyse and interpret the information being received and 'decide' on an appropriate response (many of these 'decisions' are automated – there is no voluntary control over them)
- response - the appropriate response must be initiated (e.g. muscular contraction or glandular secretion)

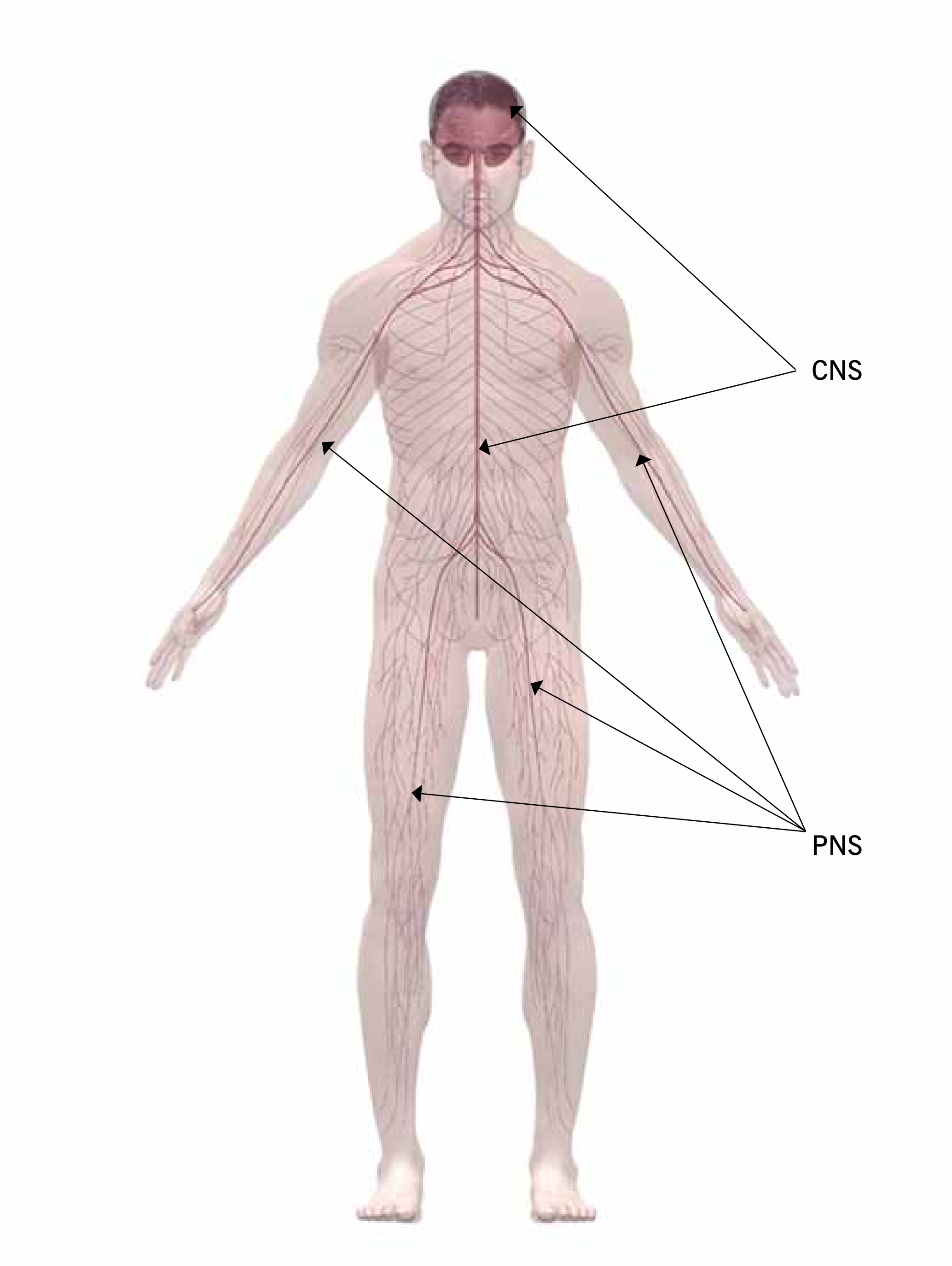
Main components of the nervous system

The nervous system can be divided into two principle sections; the central nervous system (CNS) and the peripheral nervous system (PNS).

The CNS is comprised of the brain and spinal cord and is responsible for interpreting sensory input and generating appropriate responses. These processes can range in complexity from basic reflex actions to intricate thoughts, memories and emotions.

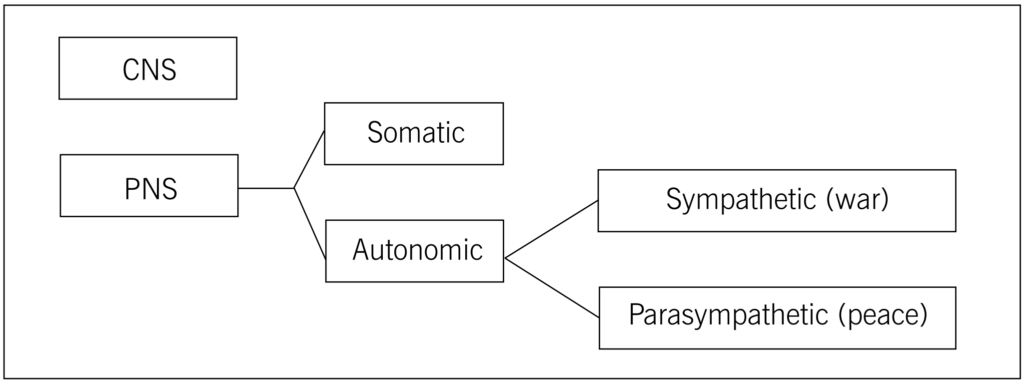
The PNS on the other hand consists of the nerves that connect the CNS to the rest of the body and the external environment. These are the means by which the CNS receives sensory input and initiates responses.

Two further subdivisions of the PNS worthy of attention are the somatic and autonomic nervous systems. The former are those nerves which serve the outer areas of the body and skeletal muscle, they are largely responsible for the voluntary control of movement. The autonomic nervous system on the other hand supplies neural input to the involuntary systems of the body (e.g. heart, digestive systems and endocrine glands).



Central nervous system and peripheral nervous system

With respect to the autonomic system, this too has subdivisions referred to as the sympathetic and parasympathetic systems. In terms of exercise, these are of interest because they serve to increase levels of activation in preparation for activity (sympathetic) or serve to decrease levels of activation during rest and recovery (parasympathetic). Owing to their roles, their actions are sometimes referred to as 'war' and 'peace' respectively.

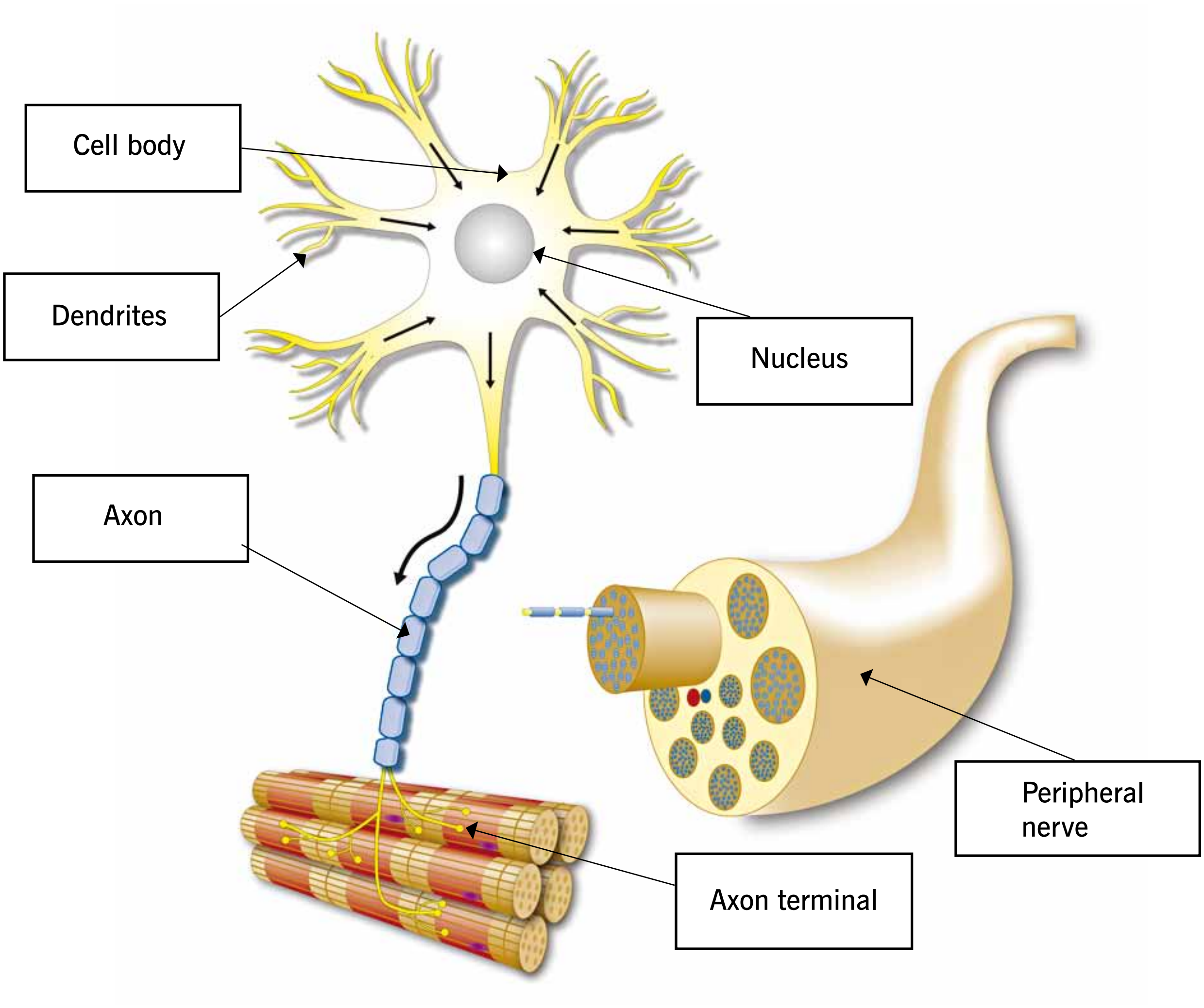


The basic structure of a neuron

In order to better appreciate the way in which the nervous system functions, it is useful to take a closer look at one of its most basic components – a neuron.

A neuron or nerve essentially behaves like any form of cable or wire, it allows signals or impulses to travel from one part of the body to another. Distances may be short for example, from one part of the CNS to another, or may be relatively long e.g. from the bottom of the feet to the lumbar region (Tortora and Grabowski, 1996). Nevertheless, different neurons possess the same fundamental anatomical features.

The cell body of a neuron contains the same basic structures as the majority of other cells in the body, such as a nucleus and various organelles (organelles are the internal organs of individuals cells. They play a fundamental role in the normal function of the cell).



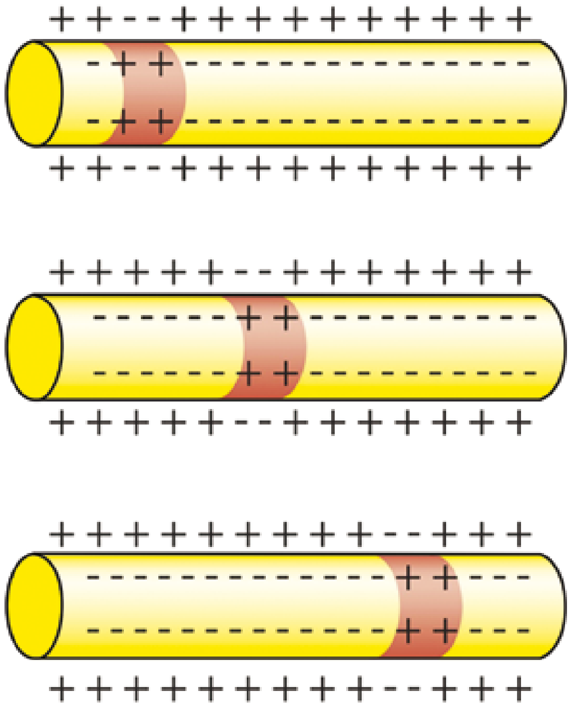
Basic structure of a motor neuron

The primary distinguishing feature of the cell body is the array of projections known as dendrites which spread out like the branches of a tree (dendro - pertaining to tree). It is these that actually 'sense' the stimulus (e.g. heat, pain or pressure).

Also running from the cell body is a long cylindrical projection called an axon; it is along this that nervous impulses travel. The distinctive covering of the axon is a lipid/protein compound (myelin sheath) that serves the purpose of insulation, it is vital for rapid transmission of impulses. At the end of the axon is the axon terminal which represents the interface between the neuron and other cells, such as other neurons or muscle cells.

Action potentials, axon terminals and neurotransmitters

The term action potential describes the wave of electrical activity that passes along electrically excitable cells, such as those found in nerves and muscles. The action potential passes along the outer membrane of the cells and is created through the controlled movement of electrolytes (sodium and potassium) into or out of the cells. The mechanisms behind this are reviewed in more detail in the muscular system section.



Action potential

At the end of the axon terminals are swellings (synaptic end bulbs) which contain small sacs of neurotransmitter, which in the case of skeletal muscle is acetylcholine (Ach).

When the action potential reaches the end of the axon terminals the Ach is released into the space at the ends. The Ach then diffuses across the space between the axon terminals and the muscle cell membrane. The Ach then binds with specialised receptors on the muscle membrane, which in turn triggers a muscle action potential. This ultimately stimulates muscles to contract. In summary, Ach enables the transfer of an action potential from the end of a neuron to an adjoining cell.

Physical activity and the nervous system

It is stressed, that in the early stages of training the majority of performance improvements are likely to be the result of changes in the way the central nervous system controls and coordinates movement. This appears to be particularly so for resistance training (Earle and Baechle, 2004).

When we perform an activity our senses provide constant feedback regarding limb position, force generation and the performance outcome (i.e. was the movement successful?). Unsuccessful or poor performances can be cross-referenced with other sensory input and a new movement strategy can be tried (Schmidt and Wrisberg, 2000). Regular training and practice cause adaptations in the central nervous system allowing greater control of movements. Thus movements become smoother and more accurate and performance improves.

The role of the endocrine system

Along with the nervous system the endocrine system helps maintain homeostasis. Instead of using action potentials however, the endocrine system exerts its influence via hormones (chemical messengers), which are produced by glands and secreted (put) into the bloodstream.

Much of the control of hormonal activity ultimately rests with the hypothalamus and pituitary gland which are located in the brain. Together they represent '… the major integrating link between the nervous and endocrine systems' (Tortora and Grabowski, 1996). Many of the hormones produced in this region directly influence the activities of other glands, thus the pituitary gland is often referred to as the 'master gland' (Tortora and Grabowski, 1996). However, for the purpose of this section we will focus on those glands and hormones directly involved in exercise activity.

Hormones

Hormones are chemicals derived from lipids or proteins. Different hormones have different chemical shapes which determine the effect the hormone will have. Each hormone will have a target cell or cells that have specific receptors in their membranes which will only be triggered by the 'right' hormone (i.e. in the same way that locks can only be opened with the right key).

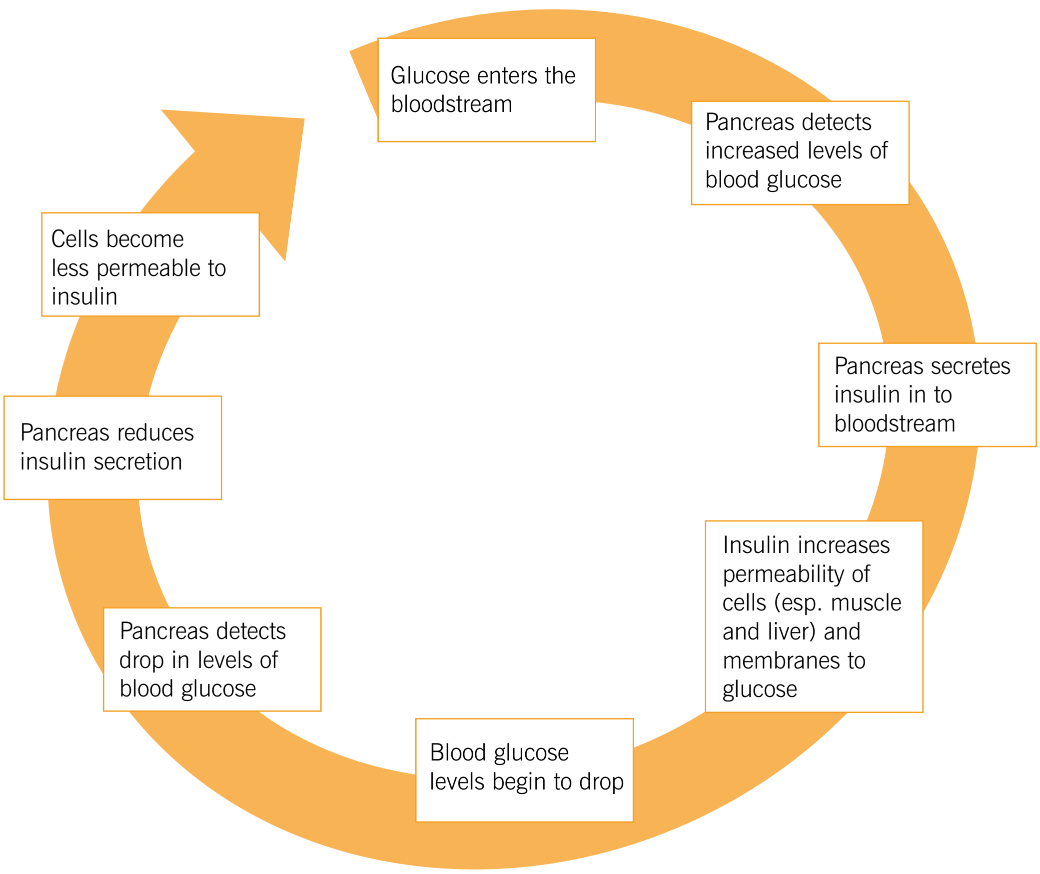
Insulin, glucagon and the control of blood glucose

The principle fuel for vigorous activity is carbohydrate (specifically glucose). It is also worth noting that glucose is the principle fuel for the brain. Large fluctuations in blood glucose levels can be extremely damaging, too little will certainly inhibit performance but could eventually be fatal, whereas too much can damage the vascular system.

Control of blood glucose levels is primarily directed by the pancreas, which occupies an area posterior to and just below the stomach. As a gland it has multiple functions, but the ones of interest here relate to the production of two hormones; insulin and glucagon.

Insulin: after consuming a meal, glucose enters the blood at the small intestine causing a rise in blood glucose levels. As this blood is circulated through the pancreas the elevated levels of glucose trigger the release of insulin. The circulating insulin binds with the receptors of its target cells (in this case skeletal muscle or liver cells) and the cell membrane becomes more permeable to glucose. Glucose then diffuses out of the bloodstream and into the cell. The net result being, a drop in blood glucose levels.

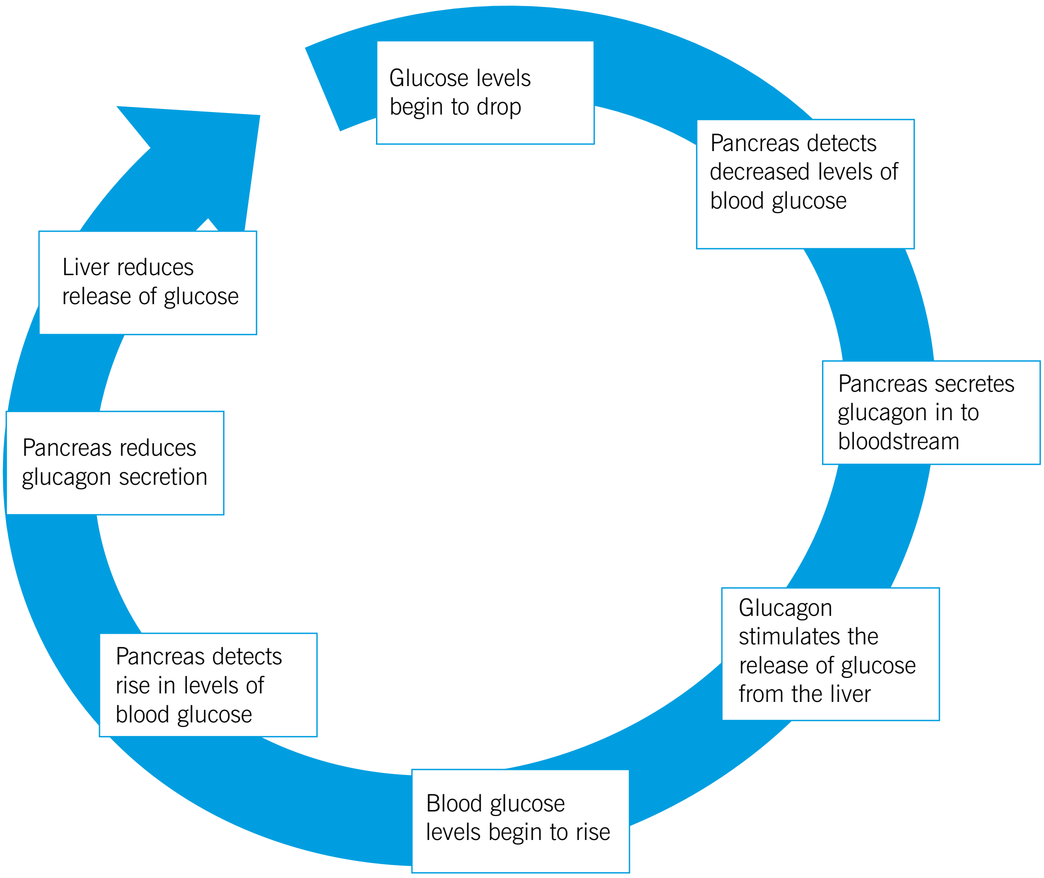
At this point, it is also worth noting that insulin encourages the synthesis (manufacture) of both protein and fat within the body. The extent to which this occurs is determined by the nature of the meal consumed and the existing nutritional status of the individual (McArdle et al. 2001, Tortora and Grabowski, 1996).



A summary of insulin action

Glucagon: in contrast to insulin, glucagon serves to maintain blood glucose levels by triggering the release of glycogen from the liver (glycogen is the stored form of glucose). In the hours following the last meal, a combination of normal metabolic processes and physical activity will begin to lower blood glucose levels (assuming nothing has been eaten in the meantime). The drop in circulating blood glucose levels triggers the release of glucagon from the pancreas. In contrast to insulin, glucagon has a much more specific affect in stimulating the liver to convert some or all of its glycogen stores back in to glucose which are then released in to the bloodstream.

The effects of exercise: understanding the effects of exercise is helpful because they help underline the interrelationship between insulin and glucagon. As activity levels increase, glucose uptake by the body's cells also increases. This is the result of an increased sensitivity of the cells to insulin, thus insulin levels will drop during physical activity (Wilmore and Costill, 2004). At the same time glucagon secretion by the pancreas increases, thus helping maintain a steady supply of blood glucose.



A summary of glucagon action

Adrenalin (epinephrine)

Adrenalin is a hormone produced by the adrenal glands, which are situated on top of each kidney. It is one of a category of hormones known as catecholamines. Essentially, these hormones help prepare the body for activity, more specifically they are part of the stress response.

In preparation for activity, the hypothalamus (part of the brain) triggers the adrenal glands to secrete more adrenalin. This will have a number of specific physiological effects that will help sustain exercise activity:

- increases heart rate and stroke volume
- elevates blood glucose levels
- redistributes blood to working tissues
- opens up the air ways

(Tortora and Grabowski, 1996; Wilmore and Costill, 2004)

Testosterone and oestrogen

Testosterone is produced in the testes of the male and in small amounts in the ovaries and adrenals of the female. Males produce up to ten times more testosterone than females (McArdle et al, 2001) and this is primarily responsible for the development of the male secondary sexual characteristics, such as facial and body hair and greater muscle mass. Oestrogen is produced primarily in the ovaries in the female with small amounts produced in the adrenals in males. Women of reproductive age have significantly higher levels of oestrogen than males which gives rise to female secondary sexual characteristics such as breast development and regulation of the menstrual cycle.

For both males and females however, testosterone pays a fundamental role in the growth and repair of tissue. Raised levels of testosterone are indicative of an anabolic (tissue building) training status. Oestrogen has many functions, but in particular has an influence on fat deposition around the hips, buttocks and thighs.

Cortisol

In contrast to testosterone, cortisol is typically referred to as a catabolic hormone (associated with tissue breakdown). Under times of stress, such as exercise, cortisol is secreted by the adrenal glands and serves to maintain energy supply through the breakdown of carbohydrates, fats and protein. High levels of cortisol brought about through overtraining, excessive stress, poor sleep and inadequate nutrition can lead to significant breakdown of muscle tissue, along with other potentially harmful side effects (McArdle et al, 2001).

Growth hormone

The name of this hormone has particular reference to its primary functions. Growth hormone is released from the pituitary gland in the brain and is regulated by the nearby hypothalamus. Growth hormone is stimulated by several factors including oestrogen, testosterone, deep sleep and vigorous exercise. Growth hormone is primarily an anabolic hormone that is responsible for most of the growth and development during childhood up until puberty when the primary sex hormones take over that control. Growth hormone also increases the development of bone, muscle tissue and protein synthesis, increases fat burning and strengthens the immune system.

Thyroid hormones

The thyroid gland is located at the base of the neck just below the thyroid cartilage, sometimes called the Adam's apple. This gland releases vital hormones that are primarily responsible for human metabolism. The release of thyroid hormones is regulated by the master gland, the pituitary. Thyroid hormones have been shown to be responsible for carbohydrate, protein and fat metabolism, basal metabolic rate, protein synthesis, sensitivity to adrenalin, heart rate, breathing rate and body temperature. Low thyroid function has become a well recognised disorder leading to low metabolism, fatigue, depression, sensitivity to cold and weight gain. The incidence of hypothyroidism today is relatively low with only 3% of the population suffering the condition.

The effects of exercise

Research has indicated that testosterone and growth hormone levels increase following strength training and moderate to vigorous aerobic exercise. It is also noted that a similar pattern seems to emerge for cortisol (McArdle et al, 2001).

The presence of cortisol in the bloodstream is often taken to be indicative of overtraining. This is perhaps a little simplistic as cortisol is a necessary part of maintaining energy levels during normal exercise activity and may even facilitate recovery and repair during the post-exercise period (McArdle et al, 2001).

Problems may arise however, as a result of extremely intense or prolonged bouts of endurance training, which have been found to lower testosterone levels whilst raising cortisol levels. Under these circumstances, catabolism (breakdown) is likely to outstrip anabolism (build up) and give rise to symptoms of overtraining (Wilmore and Costill, 2004; McArdle et al., 2001).

The respiratory system

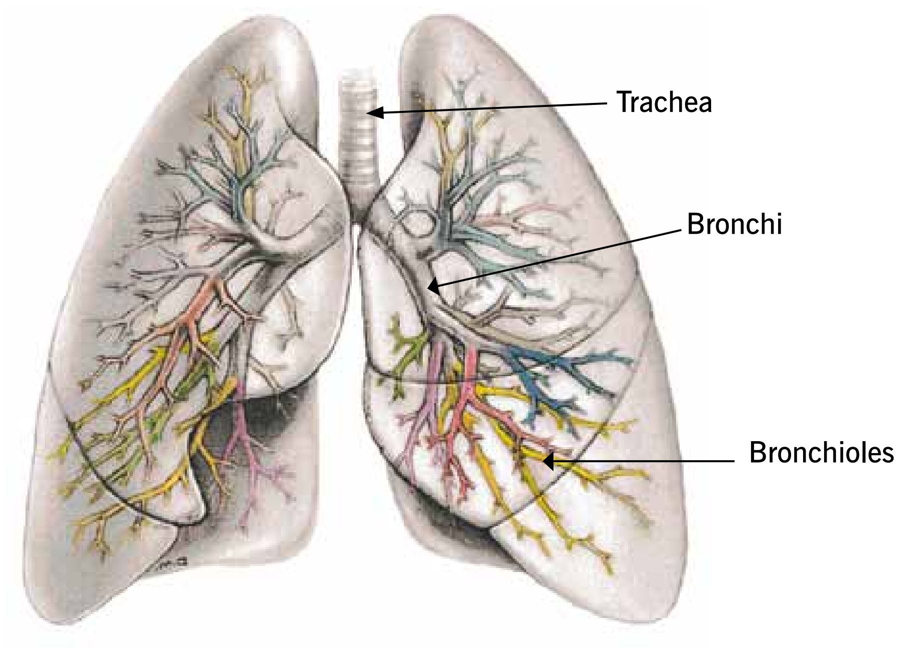
To function effectively the cells of the body need a continuous supply of oxygen and a means of removing carbon dioxide. This is achieved through the coordinated activities of the respiratory system and the circulatory system. The respiratory system's primary function is to allow the efficient exchange of gases into and out of the body. It is the interface between the external environment and the bloodstream.

The anatomy of the respiratory system

The key anatomical features of the respiratory system are illustrated in the diagram below. The upper portions of the system are formed by a series of tubes in which little or no gas exchange occurs.

At the top, the nose and mouth serve to warm and filter the air before it passes into the lungs. The back of the throat is referred to as the pharynx and extends from a region level with the nose down to the larynx. The larynx or voice box is a relatively short passage which is lined with a series of cartilaginous folds. The inner most of the folds (true vocal chords) vibrate to produce speech.

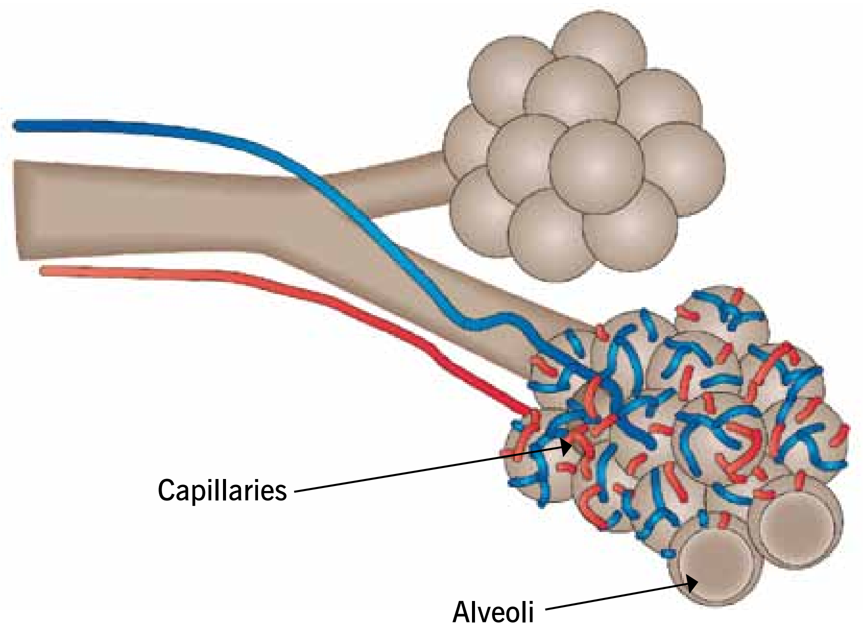
Extending from below the larynx is the trachea, which can be located just below the level of the Adam's apple. The distinct ridges that can be felt, are rings of hyaline cartilage, these provide rigidity to the trachea which prevents it from collapsing during inspiration (breathing in). At approximately mid - chest level the trachea subdivides to form two bronchi, which connect to the lungs. Within the lungs the bronchi further subdivide to form smaller bronchi, which eventually form into bronchioles, the smallest of which are referred to as terminal bronchioles. The network of vessels extending from the trachea look like the branches of a tree and is sometimes referred to as the 'bronchial tree' (Tortora and Grabowski, 1996).



Gross anatomy of the lungs

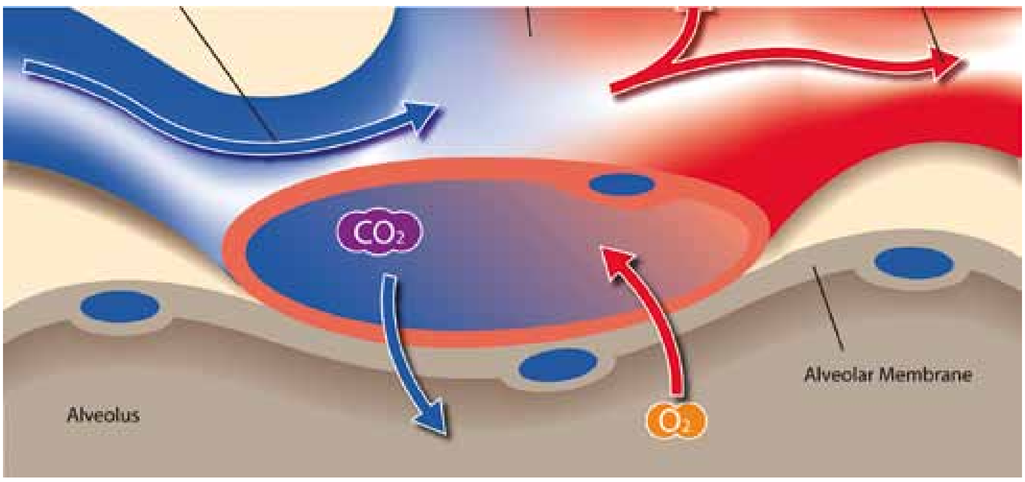
The alveoli

At the ends of the terminal bronchioles are the alveoli. These small sac-like structures mark the point at which atmospheric gases meet the blood supply. There are approximately 300 million alveoli and each has a network of tiny blood vessels surrounding them, causing the lungs to have the largest blood supply of any organ in the body (McArdle et al, 2001).



Alveoli

The membranes of the alveoli are extremely thin, thus allowing oxygen and carbon dioxide to diffuse easily in and out. The membrane of each alveolus is covered by a dense network of capillaries. The blood in these capillaries carries the waste products of respiration (carbon dioxide) which diffuse through the alveoli and are expelled when we breathe out. At the same time, oxygen diffuses out of the alveoli, into the blood and is transported back to the heart.

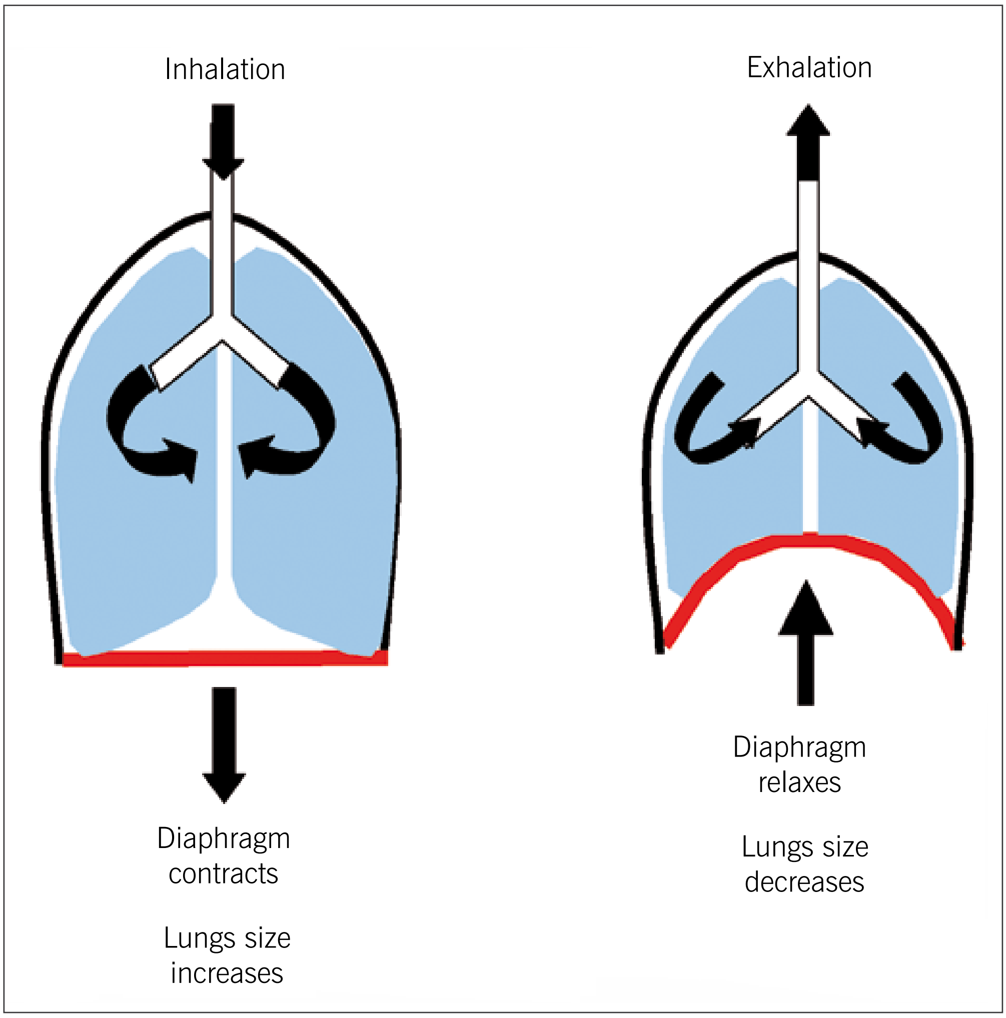


Exchange of gases in the alveoli

The mechanics of breathing

The process of taking air in to the lungs is referred to as inspiration, whereas expelling air from the lungs is referred to as expiration. The mechanisms behind this process involve muscular contractions which enlarge the chest cavity. The resultant drop in pressure causes air to be drawn in to the lungs. The primary musculature involved in inspiration is the diaphragm and the intercostals muscles, the most important of these being the diaphragm (Tortora and Grabowski, 1996).

During normal expiration, relaxation of the respiratory muscles, coupled with the effects of elastic recoil cause air to be forced back out of the lungs. When more forceful expiration is required, it is facilitated by the abdominal musculature.



The mechanics of breathing

Regulation of respiration

Regulation of breathing is controlled by the respiratory centre of the central nervous system (the medulla and the pons). This region sets the basic rhythm for breathing and coordinates the transition from inspiration to expiration. During exercise, the respiratory centre receives input from movement receptors in skeletal muscle. Also, chemoreceptors (sensors that detect chemical changes) in the medulla and arteries detect increases in levels of circulating carbon dioxide. The medulla responds by increasing the rate and depth of respiration.

The medulla also receives input from the cerebral cortex (the part of the brain associated with higher cognitive processes). This allows us to exert voluntary control of breathing where necessary, for example breath can be held when placing the head underwater.

Smoking and the respiratory system

The dangers associated with smoking are well documented. Nevertheless, it is useful to explore some of the specific effects on the respiratory system and their implications for exercise performance.

The short term effects of cigarettes on the respiratory system begin with the reflexive narrowing of the airways. The result of this being an increase in resistance to airflow (McArdle et al, 2001). Note that this is unlikely to affect light exercise, however, it may significantly inhibit vigorous exercise performance. The build up of irritants also causes an increase mucus secretion and a swelling of the cells lining the airways, thus further inhibiting airflow. The presence of carbon monoxide in cigarette smoke further restricts performance by reducing the oxygen carrying capacity of the red blood cells. Finally, smoking inhibits the natural 'cleansing' activities of the lungs causing debris and mucus to accumulate, further limiting normal respiratory function.

Over time smoking will lead to a destruction of the elastic fibres of the lungs, coupled with the collapse of the terminal bronchioles and alveoli. Eventually emphysema may develop in which exhalation becomes difficult due to the loss of the elasticity of the lungs. Emphysema represents a major limit to physical activity.

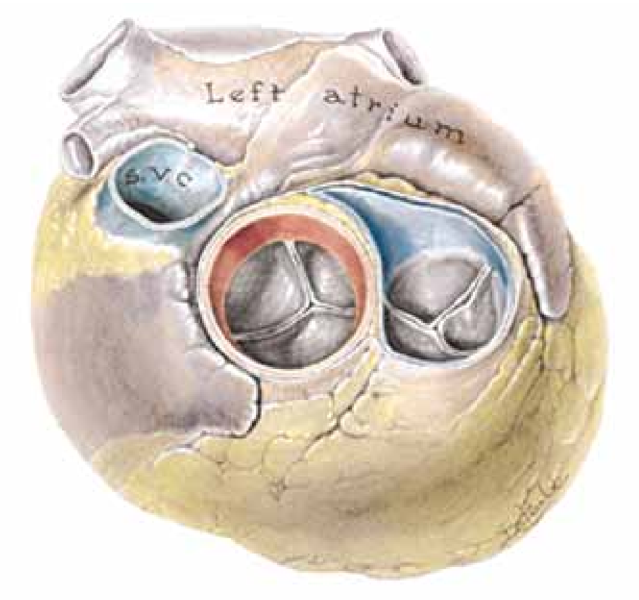
The cardiovascular system

In order to sustain exercise, the cells of the body not only require a continuous supply of nutrients, but also must have their waste products removed. The means by which this is achieved is through the cardiovascular system. In the following section, we will take a closer look at the control systems of the heart and review the key variations between the blood vessels.

The heart

The heart is a muscular pump and is the means by which blood is pushed into the tissues. It comprises of four chambers; two upper, smaller chambers called atria (called an atrium when referring to one) and two lower, larger chambers called ventricles. The predominant tissue of the heart is cardiac muscle which is referred to as the myocardium (myo – meaning muscle, cardium – pertaining to the heart).

Position of the heart



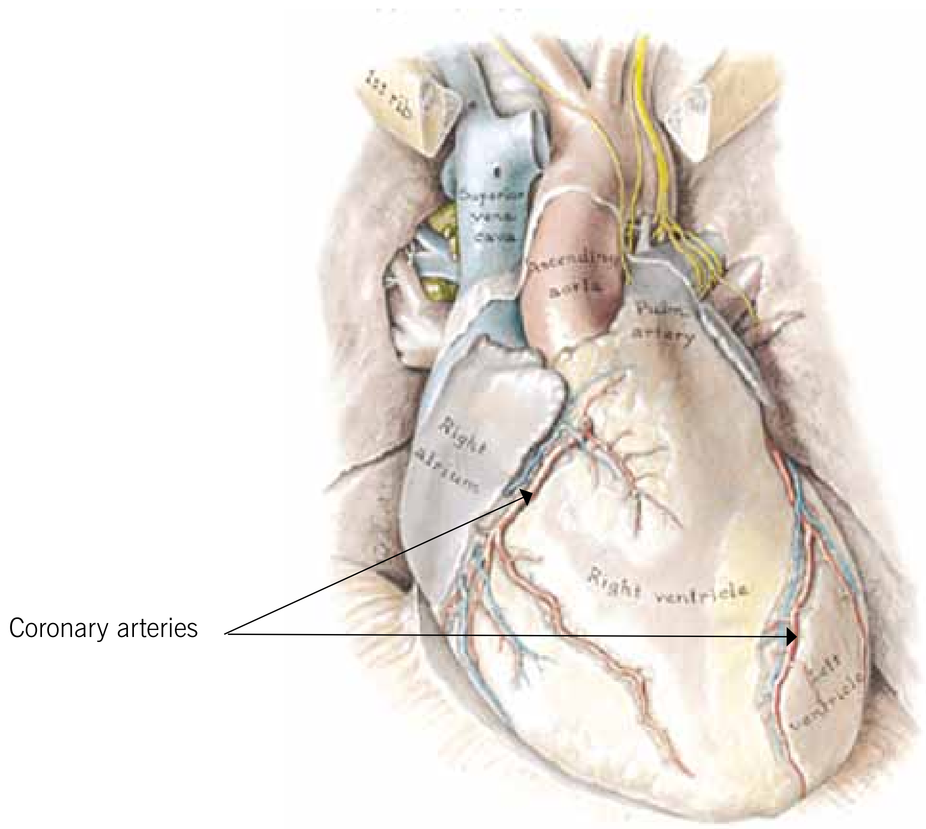
Heart valves

Valves of the heart

In order that blood can be directed effectively through the heart and into the tissues, the heart is equipped with a number of valves.

In order to prevent the back flow of blood from the ventricles into the atria, atrioventricular (AV) valves are positioned between the two chambers. As the ventricles contract, pressure rises and forces the AV valves to snap shut, thus preventing blood flowing back in to the atria and allowing blood to be directed through the arteries leaving the heart (pulmonary artery and aorta).

After each contraction there is a relative drop in pressure within the ventricles as they relax. Potentially at this point, blood within the pulmonary artery and aorta can flow back into the ventricles. To prevent this, both sets of arteries have valves positioned at the point where they emerge from the ventricles. These are referred to as semilunar (SL) valves. As the blood moves back towards the ventricles the SL valves snap shut, thus blood cannot re-enter.

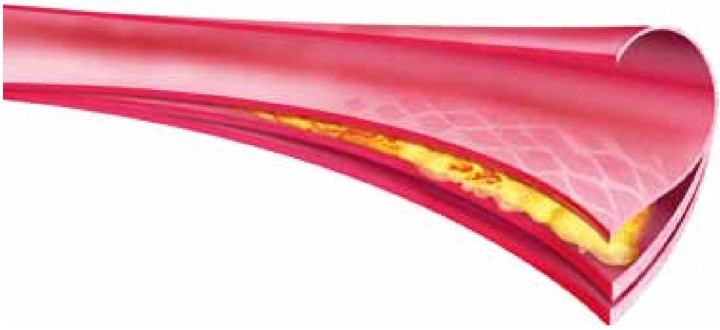


Coronary arteries

Coronary blood supply and health

The heart, like any other tissue requires a constant supply of oxygen and nutrients. To achieve this it has its own network of blood vessels. Blood is delivered to the tissues of the heart via two coronary arteries (referred to as the left and right coronary arteries). These arteries stem directly from the aorta, which is the major vessel through which blood is ejected from the left ventricle. Blood is then circulated through the cardiac tissue via a capillary network before being drained away through the coronary veins.

Most regions of the heart are served by more than one branch of the coronary arteries; should the blood flow through one vessel become reduced in someway (e.g. through heart disease), blood supply to the tissues can be maintained through collateral vessels.



Arterial fatty deposits

The coronary arteries have become renowned for their association to heart disease. The flow of blood through these arteries and arterioles is critical to the health of the heart. Multiple factors can lead to damage of these arteries and dysfunction which in turn limits blood flow to sections of the heart. Mineral, protein and fatty deposits can build up in the walls of the arteries when the internal environment allows damage to occur to the thin epithelial membrane that lines the inside of arteries. These hard mineral deposits reduce the elasticity of the arteries so they can't stretch in response to blood flow and increased blood pressure can result. If left unchecked these deposits can become so large that they can, by themselves severely limit blood flow by protruding into the inside of the artery. Sudden heart attack can often be a result of one of these deposits bursting, releasing their contents and initiating a rapid clotting process to stop the blood from escaping the artery. A forming clot can stop blood flow which results in oxygen deprivation to a section of the heart. The body responds with a rapid increase in heart rate to try and dislodge the blockage and re-establish blood flow. This very rapid beating, oxygen deprived heart is what is experienced during a heart attack.

Blood pressure

BUPA (2002) describes blood pressure (BP) as "a measure of the force that the blood applies to the walls of the arteries as it flows through them". It is measured in millimetres of mercury (mmHg) and is expressed using two numbers. The ACSM define optimal blood pressure, with respect to cardiovascular risk, as being below 120 mmHg for systolic and 80 mmHg for diastolic pressure (Franklin, 2000). Blood pressure is an expression of the arterial blood flow and the peripheral resistance the blood encounters as it flows round the body. Hypertension is the clinical term used to describe a high blood pressure (BP) of 140/90mmHg or higher (National Institutes of Health (NIH, 1997). Worldwide, high blood pressure affects 1 billion people (NIH, 2003) and is estimated to be implicated in over 7.1 million deaths; 13% of the total annual deaths (WHO, 2002). As acute exercise increases blood pressure in the short term this must be carefully taken into account prior to beginning an exercise programme with a hypertensive. Please refer to the section on hypertension.

Control of the heart - the conduction system

In order for the heart to work effectively, contraction of the various chambers must be done in a systematic and coordinated manner. To facilitate this, the heart possesses an elegant 'conduction system'. This is basically a means to direct the course of electrical activity (action potential) through the tissues of the heart so that they contract in a particular sequence.

Central to this conduction system are two small bundles of fibres located in the right atrium; the sinoatrial (SA) node and the atrioventricular (AV) node. The SA node is a collection of self excitable cells; they require no neural input and are the site where cardiac action potentials begin. From this point, action potentials spread across both atria and thus, they will contract first.

The flow of action potentials to the ventricles is controlled and directed via the AV node which is located at the base of the right atrium. The function of the AV node is to slow down the action potential and give the atria time to contract. If this did not occur the atria and ventricles would contract almost simultaneously. From here the action potential travels down a specialised nerve bundle (AV node bundle) before branching off into two bundles in the central wall of the heart (the septum). According to Tortora and Grabowski (2002) the AV node bundle is the only place where action potentials can cross between the atria and the ventricles. These two branches direct the action potentials to the base of the ventricles, so that an action potential (or contraction) will spread outwards and upward along the outer walls of the ventricles, directing the blood upwards instead of downwards

The cardiac cycle

As noted above, the conduction system allows the heart to function effectively by causing different portions of the heart to contract and relax in a coordinated manner. The cardiac cycle is described as all the events associated with one beat. The key elements of the cardiac cycle relate to the contraction and relaxation of the heart's chambers. A chamber under contraction is referred to as being in 'systole', whereas one which is relaxing is referred to as being in 'diastole'. The following is a brief summary of the key events of the cardiac cycle:

- relaxation (diastole): relaxation of the atria allows blood to refill them from the pulmonary veins and vena cava. This precedes, and continues with, the ventricular relaxation which allows blood to flow in from the atria.
- atrial systole (contraction): stimulation from the SA node causes the atria to contract and push any remaining blood into the ventricles.
- ventricular systole (contraction): the ventricles contract causing a rise in pressure. This closes off the AV valves and directs the blood to be ejected from the heart via the pulmonary artery and aorta.
- relaxation (diastole): the atria relax followed by the ventricles, until all four chambers are in diastole and the cardiac cycle begins over again.

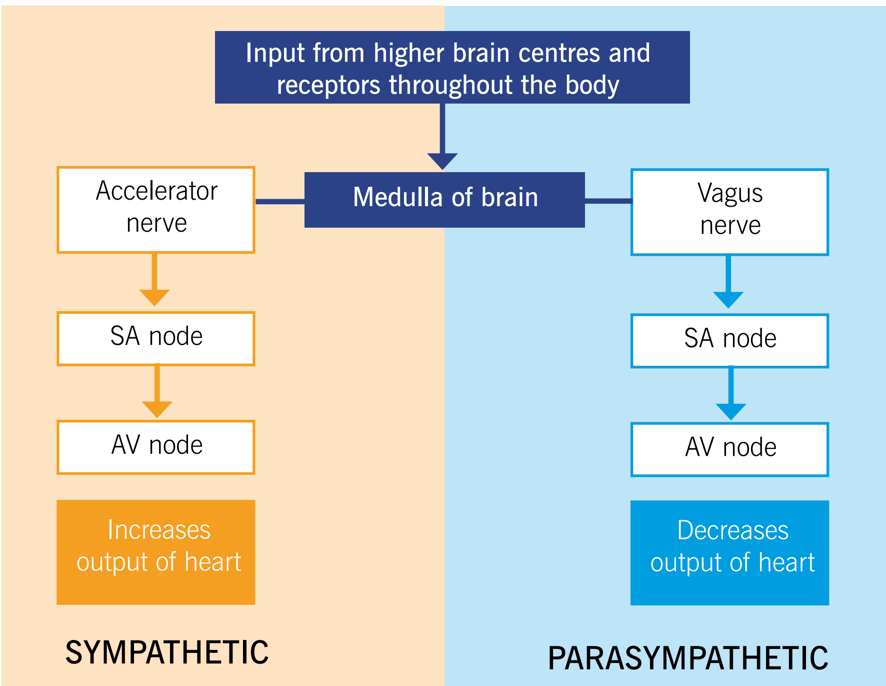
Control of the heart - the autonomic system

Whilst the SA node dictates the basic rhythm of the heart beat, the autonomic system is able to exert significant control over the amount of work the heart does. This is primarily directed by the medulla oblongata of the brain. It responds to a variety of different stimuli, such as; input from other brain centres (e.g. the cerebral cortex and the hypothalamus), chemical changes in the blood, variations in blood pressure and movement of the limbs (Tortora and Grabowski, 2002).

The activities of the autonomic system can basically be divided into two; those which prepare the body for activity (the sympathetic system) and those which return the body to rest (the parasympathetic system). The sympathetic system will increase the output of the heart, whereas the parasympathetic system will decrease the output.

When the need arises (e.g. starting to run), the autonomic system can increase the volume of work done by the heart via two cardiac accelerator nerves running from the medulla of the brain. These stimulate the SA node to generate action potentials more rapidly, as well as directly causing the myocardium to contract more forcefully (in other words, the heart beats quicker and harder).

In contrast, in a resting state, the vagus nerve (also from the medulla) causes the SA node to generate action potentials less rapidly; consequently lowering the heart rate. The SA node will naturally generate between 90 – 100 beats per minute, the influence of the vagus nerve will usually reduce this to approximately 60 – 85 beats per minute. For the trained athlete however, Wilmore and Costill (2004) note that this may drop to less than 30 beats per minute.



Autonomic control of the heart

Measuring the output of the cardiovascular system

The work done by the heart is termed cardiac output (CO) and is defined as the volume of blood pumped from the heart every minute. The determinants of cardiac output are stroke volume (SV) and heart rate (HR). Stroke volume is the amount of blood ejected from the ventricles every beat, and heart rate is the number of times the heart beats in a minute. Thus to calculate cardiac output, multiply stroke volume by heart rate:

$$CO = SV \times HR$$

Practically speaking however, it is difficult to calculate cardiac output as determining stroke volume can involve some fairly invasive procedures.

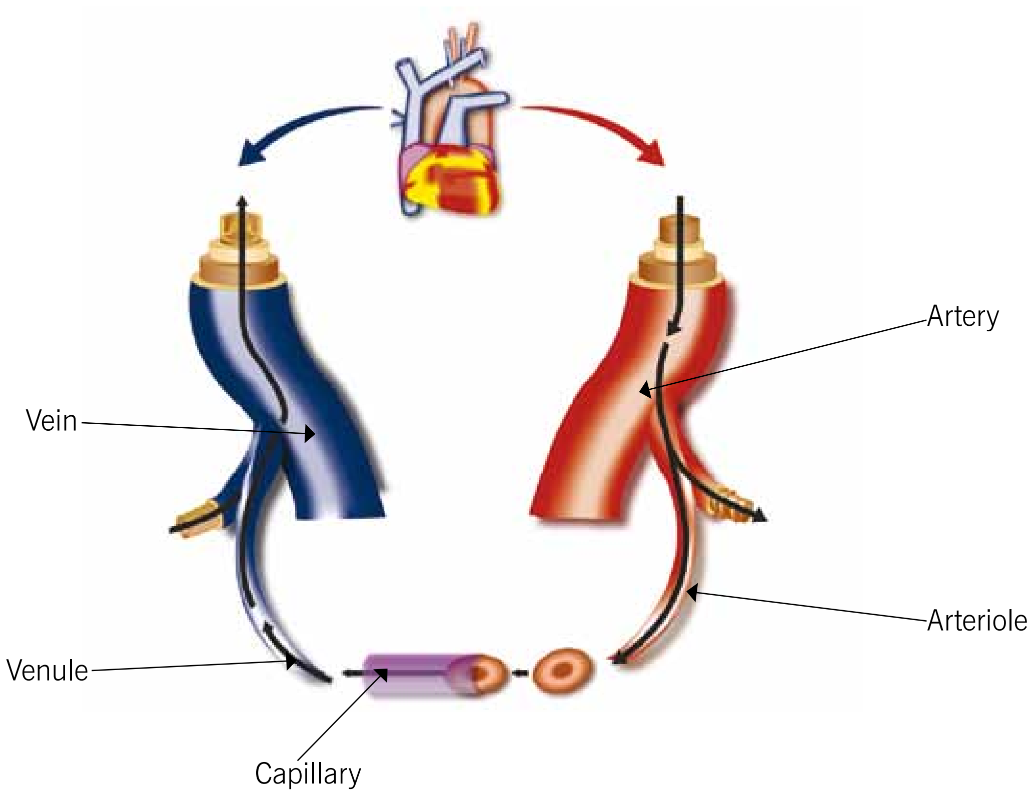
Blood vessels

Blood vessels provide the means through which blood is directed from the heart to the tissues of the body and back again. Although blood vessels vary in terms of shape and function, they all link to form a continuous loop – a circulation.

The circulatory system is composed of five types of vessels; arteries, arterioles, capillaries, venules and veins. These vary in construction and size, depending on their function and position in the body

Arteries

The main feature of arteries is that they carry blood away from the heart; consequently the pressure exerted on them is considerably higher than in other vessels. This is reflected in their construction. In contrast to other vessels, arteries are generally more robust in design; they have thicker walls, a greater number of elastic fibres and more smooth muscle. The elasticity is particularly pronounced in arteries closer to the heart, which have to accommodate large surges of pressure during ventricular contraction. The elastic recoil then facilitates the onward movement of the blood. Further along the circulation, the larger elastic vessels give way to medium-sized arteries, in which a greater proportion of smooth muscle is evident. Tortora and Grabowski (2002) note that these larger amounts of smooth muscle allow for greater vasoconstriction and vasodilatation; this adjusts the rate of blood flow to suit the needs of the structure supplied.



Cardiac cycle

Arterioles

As the arteries branch and subdivide, they become smaller. The smallest of these arteries are the arterioles. Although microscopic, they still contain smooth muscle and elastic fibres, albeit in relatively small amounts. The main purpose of the arterioles is to regulate blood flow to the capillary beds.

Capillaries

Eventually the few sparse elastic and muscle fibres of the arterioles disappear, leaving a capillary, which is comprised of only a single layer of cells.

The walls of capillaries are microscopically thin, which allows the efficient exchange of nutrients and waste products between the circulating blood and the body's cells. Just about every cell in the body will have a capillary near by, although areas of high metabolic activity will tend to have a higher density. It is also worth noting that exercise will increase capillary density in trained muscle (Jones and Round, 1990).

Venules

Having passed through the tissues, capillaries start to join with other capillaries to form venules (small veins). As with the arterioles, they have small amounts of smooth muscle tissue and elastic fibres. Their primary function is to drain the blood from the capillary beds and into the veins.

Veins

As venules connect to other venules, larger vessels are formed called veins. The pressure of blood within the veins is relatively low, and whilst veins are comprised of the same basic constituents as arteries (i.e. smooth muscle and elastic fibres), the proportions tend to be lower when compared to an artery o f a similar size. One of the major distinguishing features of veins is that they are equipped with non-return valves. These are needed because blood pressure in the veins may be insufficient to overcome gravity, thus valves help prevent reversed blood flow or pooling of blood in the limbs.

Effects of exercise on the cardiovascular system

Exercise has been shown to have very positive effects on the cardiovascular system. In healthy individuals, a regular exercise training programme including aerobic and endurance-based resistance training can be expected to bring about the following benefits:

- increased growth of cardiac muscle
- larger stroke volume
- lower heart rate for the same relative pre-trained exercise intensity
- stronger and more elastic arteries
- improved blood cholesterol markers
- increased network density of capillary beds
- increased haemoglobin count in blood
- lower blood pressure in the long term

Exercise has been shown to carry some risks in certain population groups with regard to the cardiovascular system. The following points should be considered and weighed up against specific clients prior to engaging in physical activity:

- increased blood pressure, especially during high intensity work, breath holding and use of valsalva techniques
- increased risk of light headedness or postural hypotension in some clients

Energy systems

Adenosine triphosphate: energy currency

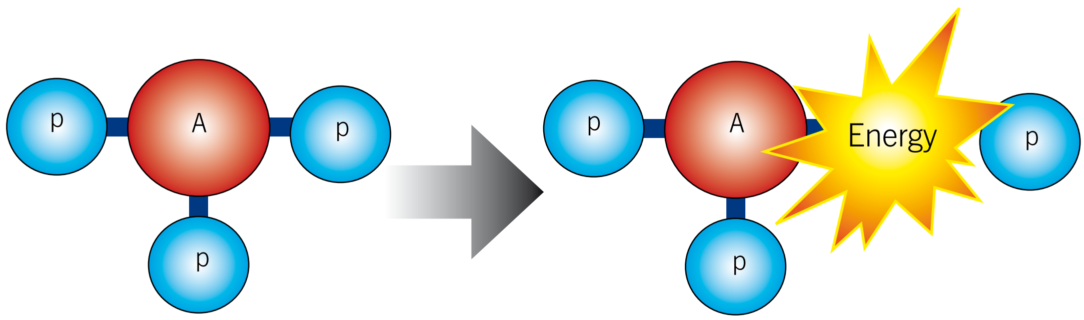
Our bodies, like all machines, require energy for movement, to produce force against objects, generate heat and to grow or repair tissue. This energy comes from one place, a substance known as adenosine triphosphate, or ATP. It is in this form that our body uses the energy provided by the macronutrients in the food we eat; carbohydrates (CHO), fats and protein. All three of these nutrients play important parts in the complex processes of ATP production, although fat and CHO are the preferred energy sources. Protein can also be used as an energy source in certain circumstances, such as when carbohydrate stores are depleted or food is scarce.

ATP provides the energy to drive the sliding filaments in muscular contractions. Therefore, as long as ATP supply is sufficient to meet exercise demands, muscular activity can continue. To meet these ATP demands the body has three distinct energy systems; the creatine phosphate system, the lactate system and the aerobic system. Before reviewing the different energy systems however, it is important to take a closer look ATP.

The structure of ATP

ATP is an energy rich compound, composed of one adenosine molecule, bound with three phosphate molecules. Energy is stored in the bonds that link the phosphate groups to the larger adenosine molecule, and are called high energy bonds. ATP releases, or liberates, its energy when one of its two high energy bonds is broken (by the enzyme ATPase), and 7.3kcals of energy are released per mol of ATP (McArdle et al, 2001). After this breaking down reaction, an adenosine molecule bound with two phosphate molecules (adenosine diphosphate, or ADP) and an unattached phosphate group is left.

Adenosine Triphosphate ⟶ Adenosine Diphosphate + Phosphate



This reaction will occur during muscular contractions and is controlled by the enzyme myosin ATPase. The ATP, which is stored on the myosin head, is broken down to ADP. Release of the subsequent ADP causes the myosin head to 'nod', which slides the actin over the myosin. The myosin head then binds with another ATP molecule, causing it to detach from the binding site. It is then able to attach to the next binding site, and perform the same routine. This will continue as long as ATP is available, nervous stimulation is present and other fatiguing factors do not interfere.

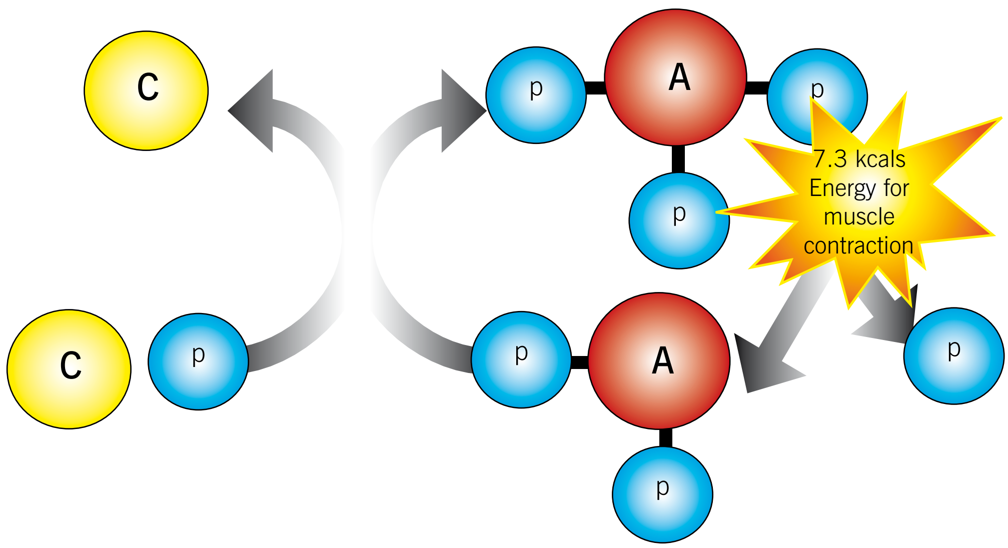
There is a very limited store of ATP within the muscles so they must be continually replenished if exercise is to continue. The energy systems serve this purpose by providing the energy to convert ADP back in to ATP, for use by the cells. These three systems are the creatine phosphate system, the lactate system and the aerobic system.

The energy systems

The creatine phosphate system: immediate energy

For high intensity, low duration activities, such as sprinting, long jumping, or shot putting, energy for muscular contraction is required quickly. This is primarily supplied by intramuscular (within the muscle) stores of ATP and creatine phosphate (CP). ATP stores are extremely limited and may only last for the first few seconds of exercise (McArdle et al, 2001). Once these have been depleted, they can be almost immediately regenerated by the breakdown of creatine phosphate. This compound, like ATP, has a high energy bond, which when broken down, will release enough energy to yield an ATP molecule. This chemical reaction is very rapid and like the ATP stores, CP stores are also limited, thus exercise will only last for a very short period of time, approximately 5 – 8 seconds. In fact, it is noted that during a 100m sprint, lasting approximately 10 seconds, runners are usually slowing down in the final few seconds; the winner being the one who slows down the least (McArdle et al, 2001).

Creatine + Adenosine Triphosphate



Creatine Phosphate + Adenosine Diphosphate + Phosphate

As this system is derived exclusively from chemical energy stored within the muscles, the process requires no oxygen (anaerobic) and places no immediate demands on fat or carbohydrate stores. Depending on the intensity and duration of activity, the recovery period for this system ranges from 30 seconds to 4 minutes (adapted from Conley, 2003).

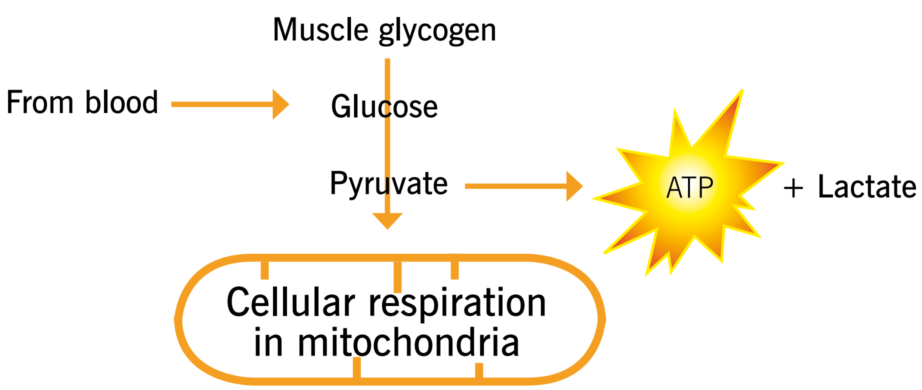
It is worth noting that a poor diet may limit CP stores, whilst resistance training and creatine supplementation may increase free creatine and phosphocreatine stores (Kreider, 1998). It is also worth noting that the long term effects of creatine supplementation are still unclear.

Lactate system

Lactic acid is named after the acid found in sour milk (Robergs, Ghiasvand and Parker, 2004) and the lactate system is generally associated with the burning sensations felt during high intensity activities. The terms lactic acid and lactate are sometimes used interchangeably, which is incorrect. Lactic acid is an acid, whilst lactate is an acid salt. This is a subtle difference, but for the purposes of this text we will be referring to lactate predominantly.

The lactate system can essentially bridge the gap between the aerobic and CP systems. It allows rapid ATP production to continue beyond the few seconds of the CP system, and at a rate significantly greater than the aerobic system can achieve. It can sustain exercise activity for between 60 – 180 seconds e.g. 400m on the track or 100m in the pool (McArdle et al, 2001).

It provides a fast supply of energy, produced by the incomplete breakdown of the carbohydrate glucose, taken from the blood, or made from the breakdown of glycogen (stored glucose). Glucose is converted in a number of stages to a substrate called pyruvate. The pyruvate will then enter one of two directions, purely dependent on whether oxygen is present or not. If there is sufficient oxygen, the pyruvate will enter the aerobic energy system. If there is insufficient oxygen to meet energy demands, it is converted, very rapidly, to lactate. This process will yield 3 ATP per glucose molecule, and does not occur in the presence of oxygen.



Glucose metabolism

It was previously thought that the conversion of pyruvate to lactate was to 'top up' the energy production of the aerobic energy system. When more energy was required than the aerobic system could provide, this conversion would lead to production of a few more ATP, allowing the athlete to work at higher intensities.

Research by Robergs et al (2004), cast severe doubt on the fatiguing effects of lactate. Traditional theories describe lactate as the cause of the burning sensations and fatigue during high intensity activities. The cause is in fact a concurrent build up of hydrogen ions, which causes pH levels to drop, a state known as acidosis. This state of acidosis inactivates various enzymes involved in energy production and can interfere with the muscles contractile ability (McArdle et al, 2001).

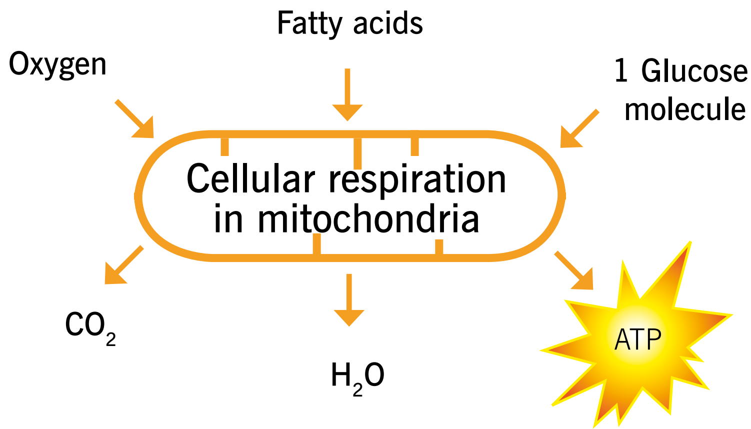
The question arises; does lactate production cause an increase in hydrogen ions, or does it just occur at the same time? Hydrogen ions are released when ATP is broken down to ADP. These are normally absorbed in the aerobic energy system. But during high intensity activities, the breakdown of ATP is occurring at a massive rate and thus the build up of hydrogen is unavoidable. Pyruvate can be used to maintain the pH and buffer these hydrogen ions, by binding with them; the result of which is the formation of lactate. This study (Robergs et al, 2004) proposes that the production of lactate is, therefore, a result of the body's attempt to prevent acidosis and is not actually the cause of it. This new theory is gaining a lot of popularity with exercise physiologists, who realised the biochemical flaws in the original theory. Despite this however, lactate levels can still be used indirectly to measure the intensity of exercise.

Even at rest, small amounts of ATP are produced using the lactate system; consequently there is always a small amount of lactate present in the blood. During low to moderate activity, energy requirements are easily met using the aerobic system, thus lactate levels remain relatively unchanged. However, when the energy demands of an activity become too great for the aerobic system to manage and hydrogen ion levels increase, the lactate system will start to be utilised and blood lactate levels will start to rise.

Although lactate levels increase, research has indicated that prolonged exercise can continue provided levels stay below a certain threshold. At some point however, the build-up of fatiguing waste products associated with the lactate acid system reaches levels sufficient to bring about the familiar decline in performance and burning sensations associated with this type of intensity. Recovery from this type of activity can vary from 20 minutes to two hours depending on intensity and duration.

Aerobic (oxygen) system

Aerobic simply means 'with oxygen', and refers to the energy system that produces ATP from the complete breakdown of carbohydrate and fat, in the presence of oxygen. The aerobic energy system is dominant during lower intensity activities when ATP demands are low and oxygen consequently is relatively plentiful.



Aerobic system

The aerobic system produces carbon dioxide, water and heat as by-products of the breakdown of CHO and fat. With the abundance of these nutrients in the body, there are almost no limits on the amounts of ATP that can be produced. There are, however, limits on the rate of aerobic ATP production. As was mentioned earlier, when exercise intensity reaches a certain point, the lactate system will start to provide more and more energy during the buffering process. The point at which this occurs will vary according to individual aerobic fitness (the ability to take in, transport and utilise oxygen). The higher the aerobic fitness the higher the exercise intensity that can be maintained without fatiguing waste products accumulating (i.e. one can run faster for longer). This point will be explored further when we address training adaptations.

Assuming the absence of any overuse injury, the recovery time from this type of exercise will be the time taken to eat, drink and replenish fuel stores.

Fuel and the aerobic system: fat (fatty acids) and carbohydrate (glucose) are the two macronutrients that supply the body with ATP during aerobic metabolism. Whether the body is at rest, or exercising aerobically, both carbohydrate and fat are required, just in varying proportions. Fat is commonly said to 'burn in a carbohydrate flame', meaning that fat cannot be broken down without carbohydrate present. The relative proportions vary depending on nutritional status and/ or exercise intensity.

At rest or during low intensity activity most aerobic energy is supplied by fat. As exercise demands increase and ATP is required more quickly, carbohydrates will begin to contribute more to the process. Although protein contains as many calories of energy as glucose, it will contribute little to energy production so long as sufficient carbohydrates are available.

Energy systems and training adaptations

Provided the right training stimulus is used, the energy systems show a variety of differing adaptations which ultimately equate to improvements in exercise performance. Even today however, many of these adaptations are not fully understood, so for the purpose of clarity only the principle ones will be discussed below.

Aerobic training adaptations

It was discussed earlier that the main limit on aerobic energy production is the ability to take in, transport and utilise oxygen (these will be referred to as pulmonary, cardiovascular and muscular changes respectively). Aerobic training has been shown to enhance all three of these areas:

- pulmonary changes - evidence suggests that the principle adaptations associated with the pulmonary system are improvements in the efficiency of the respiratory muscles. This is indicated by an increase in maximal breathing rate and tidal volume (i.e. one can breathe quicker and deeper at maximal intensities). It is also suggested that more efficient respiratory muscles are likely to use less oxygen, produce fewer waste products and thus potentially increase oxygen availability to other working muscles (McArdle et al, 2001).

- cardiovascular changes - there are a number of training adaptations associated with the cardiovascular system. Firstly, the heart of a trained individual shows significant hypertrophy and improvements in coronary blood flow, thus allowing a greater capacity for work.

  The most significant coronary adaptation appears to be an increased stroke volume. This is indicated by a lower resting heart rate, and a greater cardiac output at maximal heart rates. These improvements are complimented by an increase in blood plasma volume which may also contribute to the increased stroke volume, and oxygen transport (McArdle et al, 2001).

  The larger cardiac output of the heart facilitates a greater flow of blood to the working tissues. However, changes in the control of blood distribution, increased arterial diameter and capillary density also serve to maximise blood flow to the muscles.

- muscular changes - improved blood supply to the active muscles is matched by a greater ability of these muscles to extract and utilise oxygen from the blood. In this respect, one of the key adaptations within the muscles is an increased size and number of mitochondria. Mitochondria are the structures within the muscle cells, where aerobic ATP production takes place, thus bigger and more numerous mitochondria mean greater ATP production.

Furthermore, within the mitochondria there are significant increases in the volume of aerobic enzymes, which increases the muscles ability to metabolise (breakdown) fat and carbohydrate.

Finally, McArdle et al (2001) note that although aerobic training may not 'change' one fibre type into another (i.e. fast twitch into slow), it will maximise the aerobic potential of muscle fibres. A trained individual will tend to demonstrate a predominance of slower twitch muscle fibres, in fact McArdle et al (2001) also note that, '…highly trained endurance athletes have larger slow twitch fibres than fast twitch fibres in the same muscle'.

Training and the lactate system

Training adaptations in the lactate system are a little harder to describe. As it appears, changes in this system are related to improvements in the cardiorespiratory system. Muscles that receive and utilise more oxygen for example, are going to produce less lactic acid at a given exercise intensity.

It would also appear that regular anaerobic training improves tolerance to the build up of fatiguing waste products. As yet however, researchers can only speculate as to whether this is due to physiological adaptations or is simply the result of motivational changes.

CP training adaptations

There is little doubt that activities emphasising the CP system, such as heavy weight lifting and sprinting have a significant training effect; namely increased muscle mass and a predomination of fast twitch muscle fibres (Jones and Round, 1991). It is also reported that this form of training can significantly increase muscular stores of anaerobic fuel sources i.e. ATP, creatine phosphate and glycogen (McArdle et al., 2001).

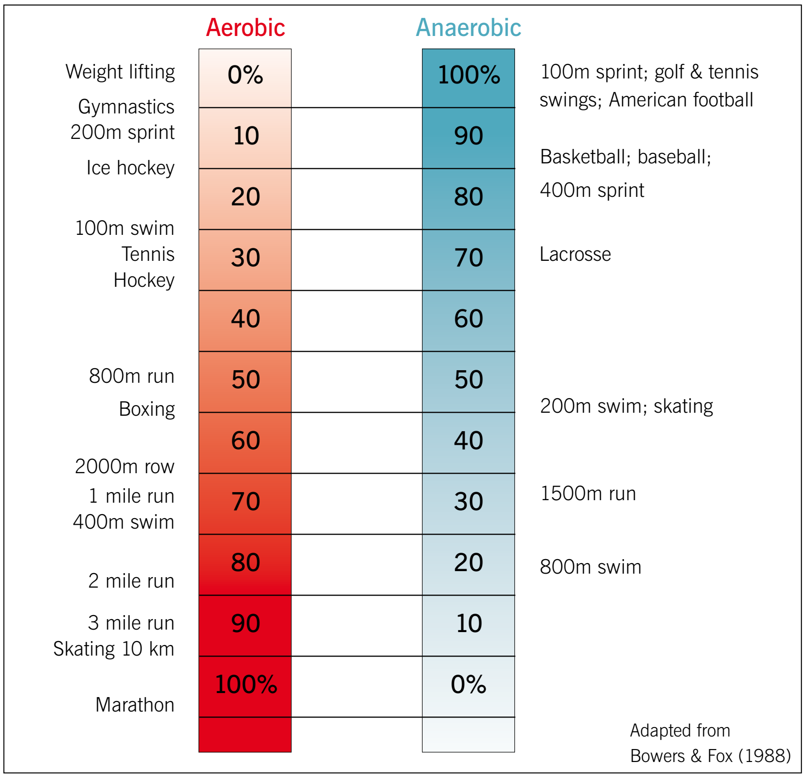
Debate continues however, as to whether this form of training improves the ability of enzymes within these muscles to generate greater amounts of ATP. To date there is little research to support this idea.

In summary, the principle adaptations associated with training the CP system would appear to be increased muscle size (fast twitch fibres) and improved activation of the muscle by the nervous system.

Interaction between energy systems

Although the energy systems are presented separately here, it is important to underline that there is considerable overlap between them. In fact, at any one time, all three systems could be providing the body with energy. However, the relative contribution of each is determined by the intensity of the activity. The table below illustrates one view of the relative contribution of aerobic and anaerobic energy systems for various sporting activities.

The energy continuum



It is worth noting that as the demands of the activity change so do the relative contributions of the energy systems. During a jog or run, when the intensity is low, ATP requirements are met by the aerobic system. At higher intensities, for example when going up a long hill, there is a greater contribution from the lactate system. At some point waste products would accumulate to a level where further increases in intensity become difficult.

Also, as one energy system becomes exhausted the others can take over. For example, a series of maximal vertical jumps will use the CP system; however, this system will be exhausted within 5 – 10 jumps. Jumping beyond this point is likely to require energy from the aerobic and lactate systems. Because the aerobic system takes a period of time to meet this increased demand for ATP, the lactate system may well provide the energy in the interim period. Jumping will continue, but performance will drop off considerably because of a build up of fatiguing waste products.

Monitoring intensity, energy expenditure and performance

For the personal trainer one of the biggest challenges is to identify the best means of monitoring intensity and performance. Objective measures, such as weight lifted, speed and distance run are important, but are unable to provide much information regarding physiological changes and sensations experienced by the exerciser. To this end, there are a number of approaches to monitoring exercise intensity and performance. These range from complex laboratory-based assessments to the use of simple question and answer procedures.

Before discussing examples of assessments however, it is important to point out that they are typically applied to activities that involve the lactate and aerobic energy systems. Monitoring internal changes during the 6 second bouts of activity associated with the CP system would prove difficult. It would appear therefore, that simple measures such as, levels of force or power generated are more appropriate for this system.

Lactate testing

It was noted earlier that levels of lactic acid provide a useful gauge as to the amount of anaerobic activity going on in the muscles. Measurement protocols typically use activities involving large muscle groups, such as running or cycling (results will differ depending on the activity being tested, thus the principle of specificity must be taken into account when selecting the mode of exercise).

Subjects are then required to perform exercise of incrementally increasing intensity. This either takes the form of a single sustained bout of exercise activity which ends when the subject can do no more (e.g. VO_2max test), or a series of increasingly intense bouts of exercise (typically 4 minutes long) followed by short recovery periods. In both protocols, blood lactate responses are measured through blood analysis and the key changes in lactate response are noted. These relate to the point at which lactic acid first starts to accumulate and the point at which lactate accumulation becomes greater than its removal.

The value of this form of assessment is that the information gained serves as a useful indicator of current training status and as a predictor of endurance-based performance. Furthermore, it can be used to establish the optimum intensity for training (McArdle et al, 2001).

Researchers may argue about the finer points of this form of assessment, however from the point of view of the trainer the main difficulty is that it is impractical to administer in a 'real' training setting. In practice, lactate measurement is still largely confined to the laboratory environment. In the field setting, the trainer must consider using simpler procedures.

Heart rate monitoring

Since the development of the wireless heart rate monitor, monitoring heart rate during exercise has become easy and affordable. The predictability of the heart rate response (i.e. it goes up when we exercise and down when we rest), coupled with strong correlations with other physiological measures, such as oxygen consumption, make it an extremely useful measure of performance and exercise intensity.

Most modern cardiovascular machines will provide exercise intensities based upon predicted heart rate responses. The typical example of this being the aerobic training zone, which is taken to be between 60 - 90% of one's maximum heart rate (220 – age) or 50 – 85% of one's VO_2max. Thus for a thirty year old client the calculation would be the following:

MaxHR: 220 – 30 = 190 beats/ min
60% of MaxHR: 190 * 0.6 = 114 beats/ min
90% of MaxHR: 190 * 0.9 = 171 beats/ min

The recommended aerobic training zone, therefore, for this client would be between 114 and 171 bpm. The calculation is relatively straight forward and with the use of a heart rate monitor it would be relatively easy to stay within prescribed training zones.

One of the drawbacks with heart rate monitors concerns the assumption that heart rate response is the same for everyone. Evidence suggests that although individual heart rate responds in a predictable manner, the magnitude of the response may differ from person-to-person. For example, women will generally have higher exercise heart rates than men (Wilmore and Costill, 2004). Also, research findings reported by McArdle et al (1992) clearly show that individuals of similar ages performing identical activities can have significantly different heart rate responses.

Whilst some of these variations could be attributed to differing levels of fitness, it is important to acknowledge the influence of genetic variations in heart rate response. In this respect, methods of monitoring intensity based on more individualised responses to exercise have proved extremely valuable.

Rating of perceived exertion (RPE)

In contrast to the methods described previously, RPE (also known as the Borg scale, after its creator - Gunnar Borg, 1998) is a subjective rating of how hard the exerciser feels they are working. Typically two scales have been used; either the 6 – 20 scale (6 = no exertion at all, 20 = maximal exertion) or a simplified 1 – 10 scale. Either way, research has indicated that when used correctly the scale provides an accurate measure of exercise intensity and seems to correlate well with other physiological measures of performance (Weltman, 1995; Wilmore and Costill, 2004). It is also extremely easy to administer. Perhaps the only real draw back with the measure is that it relies on the client being truthful about how hard an activity is!

The talk test

As with RPE the talk test relies on the response of the exerciser. Simply put, it identifies the exercise intensity at which 'normal' speech can no longer be sustained, which is indicative of the increased breathing rate triggered by exercise activity. Interestingly enough, the response is closely linked to the on-going physiological processes. The breathing rate is dictated by the volume of circulating gases in the blood which, in turn is directly determined by the level of work being undertaken by the muscles. Apart from being very simple to administer, reported research has also indicated that the talk test relates well to other measures of intensity (ACSM, 2004).

Metabolic equivalents (METs)

Another method of monitoring exercise intensity uses measures referred to as metabolic equivalents (METs). These are based on multiples of an individual's resting oxygen consumption. According to Wilmore and Costill (2004), at rest the average individual will consume approximately 3.5 ml of oxygen per kg of their body mass. This is the equivalent of 1.0 MET, thus energy expenditure at rest is 1.0 MET.

Increases in activity levels will lead to elevated oxygen consumption and therefore, the number of METs will increase. Walking for example, will consume approximately three times the oxygen as resting metabolism, therefore, is the equivalent of 3.0 METs. Running flat out for a couple of minutes on the other hand, could be rated as high as 30.0 METs.

Tables of activities and their MET equivalents are readily available, thus the MET system is a useful guide for selecting exercise intensities rather than monitoring them. It is noted, however that the MET system is unable to take into account variations in environmental conditions and changes in physical fitness (Wilmore and Costill, 2004), thus it may be best combined with other methods of monitoring exercise intensity.

Postural and core stability

Over the years 'core training' or more specifically 'core stability training' has become extremely popular, both in the mainstream gym and sports training environments. The development of a strong and stable core is championed by many as the key to improved/pain free function and sporting excellence. Understanding static and dynamic posture has also become a needed area of understanding in trying to promote sound functional movement. There are a number of areas that must be considered in gaining a complete and well balanced understanding of this controversial and often misunderstood area:

- the structures that make up the core
- the function of the core
- core activation as the foundation to good posture
- what equipment is commonly used in core training
- exercise prescription

Core structure

Quite simply, if the arms and legs are discounted, the core is what remains. Often the core is considered to include only the abdominal and lower back muscles. This is too narrow a view since when discussing the core muscles the powerful hip and upper back muscles should not be overlooked.

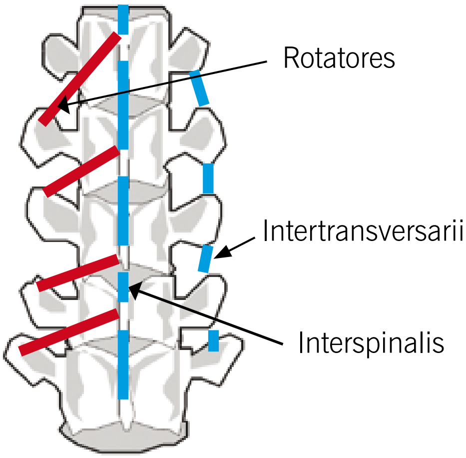
To truly appreciate the structures involved, it is useful to think of the body as being composed of a series of muscle layers - deep, middle and outer.

Deep muscle layer (position sense muscles)

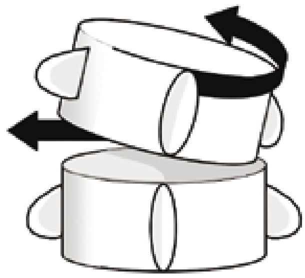
Movements of the spine and extremities can be divided into two categories, physiological and accessory movements. Gross physiological movements are responsible for large motions of the body and allow many functional tasks, such as bending and lifting, to be performed. In contrast, accessory muscles are responsible for controlling movements that occur within a joint, an example would be when bending to pick up an object from the floor the spine moves into a flexed position, but there is also accessory movement at each vertebral segment. Each segment depending on the task will bend, slide (shear) or rotate on top of each other. To control all accessory motions, there are small position sense muscles that cross from one vertebral segment to another.

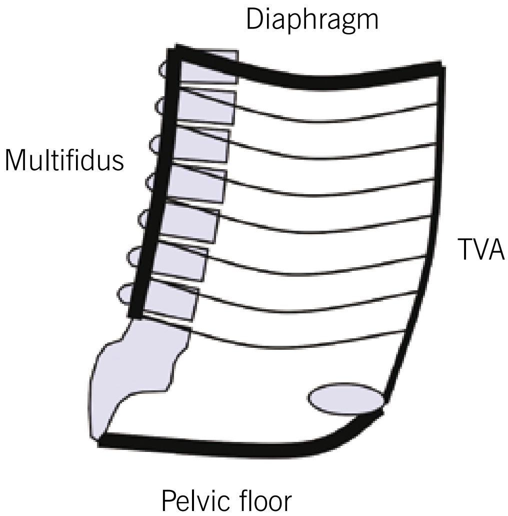
It is of vital importance to have good position sense muscle function if injury is to be avoided. McGill (2002), showed through monitoring the electrical activity of muscles that even small-uncontrolled movements of the spinal segments could lead to significant impairment.

Position sense muscles



Accessory movements





Middle muscle layer (inner unit)

Middle layer muscles include the transversus abdominis (TVA), internal obliques, lumbar multifidus, diaphragm and pelvic floor. When these muscles contract they create a non-compressible cylinder where the spine is stabilised and forms the working foundation from which the arms and legs can function optimally.

Richardson et al (1999), showed that inner unit activation occurs prior to involvement of the extremities and that faulty inner unit recruitment increased the likelihood of low back dysfunction.

Inner unit muscles

Outer muscle layer (outer unit)

Outer layer muscles include rectus abdominis, external obliques, erector spinae, latissimus dorsi, the gluteals and the adductors and form muscle slings. These muscle slings contribute to the ability to maintain an optimal working relationship between joints and to integrate the various body segments for successful motion.

Note: It should be seen that the core is made up of muscles from all three muscle layers.

An example might be lifting shopping bags from the boot of a car. First, the hips and trunk need to stabilise, then the shopping bags need to be brought closer to the body to reduce the load. Activation of muscles such as latissimus dorsi and biceps brachii perform the action of drawing the shopping closer to the body. However, all this can only be done successfully if all muscle layers contribute.

Core function – fundamental principles

Defining core function

Elphinstone and Pook (1998), define the functional role of the core as:

> *"The ability of your trunk to support the effort and forces from your arms and legs, so that muscles and joints can perform in their safest, strongest and most effective positions."*

The core (trunk) can be thought of as the 'crossroads' of the body, providing a link between the lower and the upper body.

With the above in mind, the main focus of core training is to address any functional deficit in trunk stabilisation and/or movement in order to provide the necessary spinal support and a strong and adaptable platform for the actions of our extremities.

The risks of instability and postural deviation

Panjabi (1992) defines clinical spinal instability as:

> *"A significant decrease in the capacity of the stabilising system of the spine to maintain the intervertebral neutral zones within physiological limits which results in pain and disability".*

Failure to stabilise/control core movement increases the risk of acute (short term) and chronic (long term) injury to the vertebral column. The key role of the trunk muscles in providing stability to the lumbar spine is well established (Granata and Marras, 2000). Many studies (Richardson et al, 1999; Hodges 2001; Hodges et al 2003) have identified changes in trunk muscle recruitment in clinical low back pain either as a contributing factor to the development of pain or as a result of pain.

It should be noted, that our increasingly sedentary lifestyles do little to promote the optimal function of the core. For example, habitual seated positions do little to promote neutral spines (see note below on the importance of a neutral spine position), but rather promote flexed postures which actually place the core at a biomechanical disadvantage. Similarly, the use of back rests reduces the need for core activation, therefore, increasing the risk of acute and chronic injury to the spine and its associated structures.

Just as a sedentary lifestyle can have a negative impact on core function so too can some of our exercise choices. Within the fitness industry, for example, there is often an over reliance on fixed path resistance machines. Machines are popular choices with both trainers and clients for many reasons; since they offer a supported environment they place few if any demands on the core musculature. These machines also train the body in terms of individual muscle groups and so do little to promote the integrated function of our various body parts. So in effect, machines train us to be strong in isolated muscle groups whilst placing limited demands on the core – if not supplemented and balanced with exercises that progressively challenge the core, this is a recipe for dysfunction and injury.

Postural deviations such as kyphosis or lordosis also create muscular dysfunction around the core and reduce the ability to hold good form and maintain a neutral spine during exercise and activity. When the exercise increases the forces placed through the joints and the core, the muscles will shift into their 'strongest' positions, which inevitably falls in line with their dominant posture. The images below show a woman whose core has been challenged during a weighted squat. Her dominant lordotic posture is evident as she squats despite her efforts to maintain good neutral posture she has excessive flexion at the hip and too much extension in the lumbar/thoracic spine. The abdominals, hamstrings and gluteals in this scenario are in a relatively lengthened position compared to the much shorter lumbar erectors, multifidus, and iliopsoas muscles. This illustrates how postural deviation can affect core function through all exercises not just those specifically chosen to target the core muscles. Kyphotic and scoliotic deviation will affect functional movement in a similar way by drawing movement patterns towards the dominant postural position.

It is often the case, but not the rule, that a predominantly sedentary lifestyle and becoming overweight can lead to postural deviations and weakness within core musculature. Too much time in a seated position can lead to reductions in core muscle activation and a lack of neural drive, so that even relatively light loads placed upon the core muscles exceed their ability to cope. Abdominal obesity shifts the centre of gravity forward which in turn leads to an increased chance of postural deviations like a lordotic lumbar curve or a sway back posture where the hips are translated forward. Such deviations all lead to faulty loading patterns which increase the strain on the spine and surrounding joint structures.

Passive support – ligaments and discs

Spinal discs sit between each pair of vertebrae, providing both shock absorption and an element of support for the spine. Ligaments run the entire length of the vertebral bodies (e.g. the anterior and posterior longitudinal ligaments) and between spinous and transverse processes (interspinous and intertransverse ligaments) and also help guide and support spinal movement. However, despite, these passive structures, without its supporting musculature the human spine is inherently unstable and can only withstand a load of 4-5 lb before it buckles into flexion (Panjabi et al, 1989).

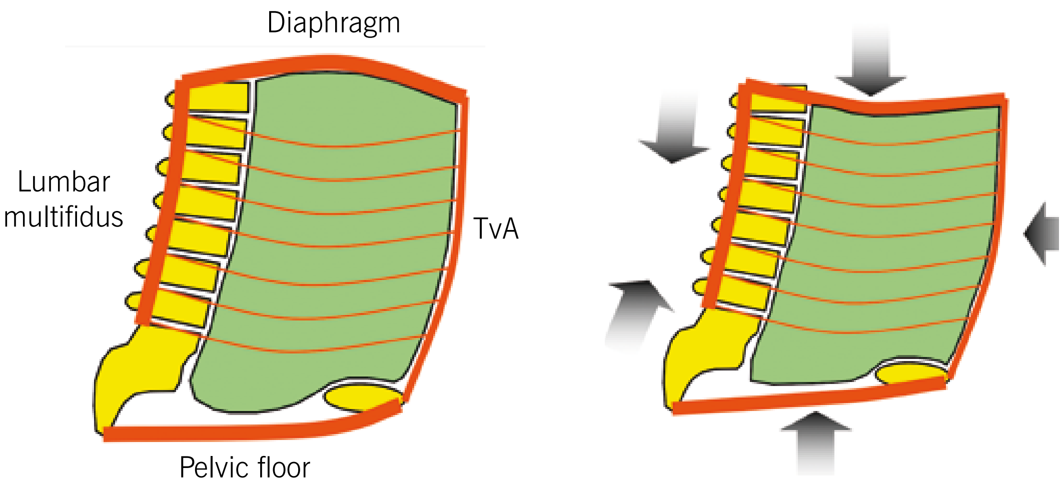
It is, therefore, a basic principle of core stabilisation that during movement, a failure to activate local stabiliser muscles will result in excessive forces being placed on these passive structures.

Intra-abdominal pressure (IAP)

To maintain stability and reduce pressure on the intervertebral discs in the lumbar spine some identifiable core muscles contract simultaneously causing an increase in pressure within the abdomen.

As Norris (2000) states:

> *"Intra-abdominal pressure is created by synchronous contraction of the abdominal muscles, the diaphragm, and the muscles of the pelvic floor."*



Intra-abdominal pressure

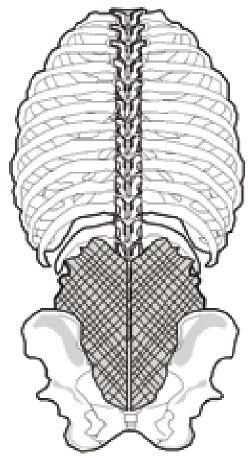
The trunk should be thought of as a cylinder. The diaphragm forms the lid of the cylinder and the pelvic floor the base. The walls of the cylinder are created by the deep abdominals (TVA and the internal obliques).

During contraction of the abdominals the walls are pulled in and up while if a deep breath is taken, the diaphragm is lowered, compressing the cylinder and the abdominal contents from the top. Provided that the pelvic floor (the base of the cylinder) has sufficient integrity, it will resist the action of the diaphragm and the downward displacement of the internal organs (viscera). In this way, a non-compressible cylinder is created. This gives the torso stiffness and a more rigid structure. Such a structure is better able to resist the stresses placed on the lumbar spine, particularly during lifting movements. The spine is stabilised and forms the working foundation from which the arms and legs can function optimally. As Twomey and Taylor (1987) state, making the trunk into a more rigid cylinder reduces axial compression and shear loads and transmits loads over a wider area.

Note: a good example of the natural functioning of IAP would be when muscles contract reflexively to defend the abdomen from a direct blow.

The thoracolumbar fascia (TLF)

The TLF is a broad, flat fascial sheath that stretches across the thorax and lumbar region and is involved in passive and active stabilisation of the spine. It serves as an anchor for many muscle attachments, especially that of the TVA, and aids stability for the second to the fifth lumbar vertebrae.



Thoracolumbar fascia

The function of the TLF can be likened to the tightening of the strings on a girdle around the waist. Stability is created by lateral tension or a pulling action from the TVA and internal obliques that is transferred to the fibres of TLF creating a hoop-like tension through the TLF. This tension produces an extension force on the lumbar spine, which resists the natural pull of lifting movements into spinal flexion. This phenomenon has been referred to as TLF gain (Gracovetsky, 1985).

The TLF can be seen as adding to the tension and the ability to resist stress placed on the walls of the non-compressible cylinder created by IAP and therefore, enhancing our core stability.

Neutral spine

A neutral position for the lumbar spine is midway between full flexion and full extension as determined by the position of the pelvis. The greater the anterior tilt of the pelvis, the greater the spinal extension, while the greater the posterior tilt of the pelvis, the greater will be the degree of spinal flexion.

A neutral spine position is maintained exclusively through muscular activity, thereby placing minimal stress on the passive structures of the spine (ligaments and discs). Furthermore, since in the neutral position the postural alignment of the spine is optimal, this is also the best position from which the trunk muscles can work. Consequently, teaching clients to identify and maintain a neutral spine is a key part of any back stability programme.

Integrated core function

While the above description of the IAP mechanism reveals a significant role for the inner unit musculature in providing core stability we should not overlook the contribution of the more superficial outer unit musculature in this stabilising role. As an example of this, it should be seen that the contraction of gluteus maximus muscles via their attachment to the TLF will have the effect of tightening this fascia. Consequently, efficient gluteal function is fundamental to back stability.

Activating the core

Abdominal bracing

The act of tightening or stiffening ones abdominal muscles (as if bracing for a punch in the stomach) is believed (McGill, 2002) to be the most effective method of stabilising the core. This bracing technique activates a simultaneous or co-contraction of the abdominal and lumbar extensor muscles. McGill recommends the performance of an abdominal brace in exercise/rehabilitative and functional situations (e.g. picking up a child or getting in and out of a car).

To teach abdominal bracing McGill recommends stiffening a joint, like the elbow, to demonstrate. Actively stiffen the biceps and triceps and palpate the muscles on each side of the joint to get the idea. This can be practiced at different percentages of maximum contractions e.g. 10, 20, 50%. Once the basic idea has been grasped replicate this co-contraction on the torso. With abdominal bracing the abdominal wall is neither pushed out, nor pulled in.

The abdominal brace

Core equipment

Equipment such as stability balls, BOSU and wobble boards are commonly associated with training for core stability. What all these mediums have in common is that they all provide an unstable surface and thereby serve the purpose of amplifying the instability of the user. This enforced instability increases the activation of the core musculature which, has to work harder to provide the necessary stabilisation.

The heightened activation that these training mediums provide means that their use is appropriate as a starting point for any programme targeted at the core musculature. What must be remembered is that the core will be at work in all situations and, therefore, core training is not solely about the use of these mediums. Consequently, in the interests of maintaining the functionality of our training at some point in the exercise progression these mediums should be sidelined in favour of exercises performed on a more familiar surface – the floor!

Exercise prescription

To progressively train the core muscles, select exercises based on increasing amounts of core contribution. This may be done using a variety of different training modalities, body positions and movements. A possible exercise progression is set out below. This progression first utilises floor-based positions and unstable surface training to address any existing deficiencies in core function. Clients would then be given more functional exercises in standing positions which seek to place demands on the core in all three planes of motion (sagittal, frontal and transverse).

Core progression

Reasons for participant exclusion

All trainers should be aware that there are some conditions which, may be aggravated by physical activity and are beyond the scope of their practice. These would include a prolapsed/bulging intervertebral disc or facet joint syndrome. Such conditions should be identified during a thorough consultation/screening process.

Flexibility and stretching

Flexibility definitions

There are a number of definitions that can be used when referring to flexibility:

- a measure of the range of motion (ROM) available at a joint or a group of joints (Cotton, 1997)
- the ability to move the joints in the needed range of motion demanded by the sport (Kraemer and Gomez, 2001)
- the ability to readily adapt to changes in position or alignment; may be expressed as normal, limited, or excessive (Kendall et al, 1993)

Benefits

- increased range of motion
- reduced muscle tension and increased physical and mental relaxation
- reduced risk of joint sprains or muscle strains
- reduced risk of back problems
- decreased muscular soreness (DOMs) associated with other exercise activities
- decreased muscle viscosity, causing contractions to be easier and smoother
- improved co-ordination by allowing for greater ease of movement
- improvement and development of body awareness
- improved capability for circulation and air exchange
- improvements in posture

(adapted from Alter, 1998; Fredette, 1998)

Perhaps, a further benefit that could be added to this list is the opportunity that flexibility work brings for interaction between the client and trainer. Those forms of passive stretching that rely on the personal trainer directing, and physically moving the client into stretch positions, demand a great deal of the trainers communication and general client care skills. This therefore, is an opportunity to win client confidence and to demonstrate skills.

Factors affecting flexibility

Age

Young people are normally more flexible than older people (Wilmore et al, 1978). Babies and infants are very flexible and start to lose this natural flexibility as soon as they start to walk (when the joints become weight-bearing and need more stability). As we get older, muscle contractility remains, whilst elasticity is lost, resulting in tighter, stiffer muscles. There is also a reduction in activity levels as we age, which will cause a decrease in flexibility.

Gender

Studies have shown females to be more flexible than males in most joints and to remain so throughout adult life (Getchell, 1979). The reasons for this are uncertain, but may be attributed to the structural or anatomical differences or different activities and training experiences of boys and girls early in life.

During pregnancy and in the post-natal period, women produce excess amounts of a hormone called relaxin to assist the birth process. The effects of relaxin are not restricted to solely the pelvic area, but act throughout the body, allowing greater flexibility than normal. Small levels of relaxin are constantly present, and will fluctuate slightly throughout a normal menstrual cycle.

Temperature

An increase in temperature due to either direct heat or the weather can increase the range of motion and elasticity of muscle and tendons. Conversely, a decrease in temperature can result in a decrease in flexibility of as much as 20% (Wear, 1963).

Exercise and resistance training

Active people tend to be more flexible than those with a sedentary lifestyle (Getchell, 1979). This is especially the case if the activity involves stretching exercises. Although a comprehensive resistance training programme may increase ROM (Leighton, 1964), resistance training exercises with a limited ROM and higher loads may actually decrease ROM (deVries, 1974).

Heredity

Flexibility can be an inherited characteristic, as well as an acquired one. Some people are born with a naturally excessive ROM. This can create a greater potential for injury (e.g. joint dislocation) and it may be necessary to concentrate on strengthening the muscles acting over the joint in order to increase stability.

Fashion

Female clients who constantly wear high heels may find that the muscles of the lower limb (gastrocnemius, soleus, peroneals) adaptively shorten over a period of time.

Physiology of stretching

The muscle spindles and golgi tendon organs (GTOs) have an influence on flexibility and stretching because of the reflex actions that they stimulate.

Muscle spindles are located within muscle fibres and their main function is to send messages back from the muscle to the central nervous system to inform about its state of stretch. If the muscle is stretched, distortion of the muscle spindle causes the myotatic reflex (automatic contraction) to come into play, thus avoiding damage through over-stretching. This muscle spindle activation (muscle contraction) is felt as the tension of the stretch. The amount and rate of contraction elicited from the stretch reflex are proportional to the amount and rate of stretching. Hence, the faster and more forceful the stretch, the faster and more forceful the reflex contraction of the stretched muscle; therefore, the greater the likelihood of the muscle tearing (particularly in an untrained muscle).

GTOs are sensory nerves located near the musculotendinous junction. They are activated by a contraction in a muscle and help prevent excessive tension occurring within the muscle, or the tendon of that muscle. In contrast to the muscle spindles, stimulation of the GTOs will cause a reflex relaxation of that muscle (the inverse stretch reflex). This resulting relaxation is important for certain stretches because the inhibition of the muscle in which they are located, will allow muscle fibres to lengthen and stretch further.

Relaxation that occurs in the same muscle because of GTO activation is called autogenic inhibition (Condon et al, 1987). This is achieved by contracting a muscle immediately before passively stretching it. The contraction will increase GTO activation, thus increasing the subsequent muscle relaxation during the stretch. Reciprocal inhibition is the relaxing effect that occurs in a muscle when the antagonist is contracting (Condon et al, 1987). This occurs to allow an easier contraction of the antagonist. Hence, contracting the antagonistic muscle will allow for a greater stretch in the muscle being elongated.

The various forms of passive stretching to be discussed in detail in this section rely on the exploitation of both the autogenic and reciprocal inhibition mechanisms to enable the trainer to move and encourage the client into a greater range of motion.

Methods of stretching

There are several methods of stretching muscles:

Method of stretching	Type of stretching	Example
Active stretching	Static Dynamic Ballistic	Standing chest stretch Leg swings Toe touches
Passive stretching	Static PNF	Wall chest stretch Supine partner hamstring stretch

Active

Active stretching is accomplished using antagonist muscles and without assistance from an external force or object (Alter, 1998). It involves actively contracting one muscle or muscle group in order to stretch its opposing muscle group. For example, pectorals actively contract to stretch posterior deltoids and tibialis anterior actively contracts to stretch gastrocnemius. This type of stretching is very important for athletes, because it is an essential aspect of dynamic flexibility and thus has a greater correlation with sports performance than passive stretching (Iashvili1983).

Passive

This is where another body part or external factor, such as a wall or a partner, is used to facilitate the stretch. For example, a lying hamstring stretch where the hands are held behind the thigh or on the calf. This method is used by physiotherapists to increase joint range and muscle length. A trainer partner can assist by gently pressing parts of the subject's body through full range. Great care and communication is required between partners using this method and so it is not recommended for beginners. Applying the external force incorrectly, excessively or too quickly may cause the stretch reflex to initiate, perhaps causing injury. However, it can be beneficial if the agonist is too weak and will provide a greater ROM than active stretching (Alter, 1998).

Types of stretch

Ballistic

This form of stretching involves quick, repetitive bouncing or bobbing actions. It is undertaken in order to increase the stretch beyond the muscle's normal range using momentum and body weight. It is generally considered unacceptable for the average exerciser, due to the intramuscular damage that may occur as a result of the stretch reflex. These stretching exercises can produce muscle soreness and even losses in resilience and elasticity. However, they are sometimes necessary as a more radical method of stretching adhesions and stubborn fibrous tissue in physiotherapy and rehabilitation.

Dynamic

This is similar to ballistic stretching, however, the limb movements do not end with bouncing or jerky movements, but instead, are performed under control (Alter, 1998). These stretches should mimic the movements of the following sport or activity and act as a kind of rehearsal.

- perform 10-15 repetitions of each stretch under control, gradually increasing the ROM

Static maintenance

Static maintenance stretching is where the muscle is taken to the end of its normal range and held without bouncing. These are short stretches, held for 10-15 seconds (Moffat, 1988), and are used to maintain the normal length of the muscle. Following repeated contractions during exercise, the muscle becomes shorter and thicker and a maintenance stretch is used to return the muscle to its normal length. The following guidelines should be observed:

- take the stretch to the point of bind, maintaining good alignment and posture
- hold for 10-15 seconds
- repeat the stretch if desired

Static developmental

These stretches are used in flexibility training to develop the length of the fibres themselves, thereby increasing range of movement at a joint. The following guidelines should be observed:

- take the stretch to the 'point of bind', maintaining good alignment and posture
- hold for 10 or more seconds, until the tension within the muscle has reduced
- relax and passively increase the ROM of the stretch until tension is felt again
- again hold for 10 or more seconds, until the tension within the muscle has reduced
- again increase the ROM of the stretch until tension is felt again
- hold until the tension reduces, then slowly return the limb to its normal position
- repeat the stretch if desired

Muscle energy techniques (METs)

MET is a form of passive stretching from the world of osteopathic technique. According to Chaitow (1996), MET, "…targets the soft tissues primarily, although it also makes a major contribution towards joint mobilisation…". The technique itself evolved from the rehabilitative technique known as proprioceptive neuromuscular facilitation (PNF), developed by Herman Kabat in the late 1940s and early 1950s. Like PNF techniques, MET commonly uses an isometric contraction of the target muscle before the stretch is applied. MET, unlike PNF (which uses near maximal muscle contractions), uses only minimal force during the isometric phase. The stretching phase is generally, though not always, done passively.

Perhaps the main form in which MET is applied is post isometric relaxation (PIR).

The following is an example of a hamstring stretch, utilising PIR:

- under the trainer's instruction the client should adopt a comfortable and manageable position
- the trainer explains to the client what is to be done and how the technique is to be carried out
- the trainer lifts the leg into hip flexion and takes the passive stretch to the point of bind, maintaining good alignment and posture throughout
- the trainer holds the limb at the point of bind for 10 or more seconds, until the tension within the muscle has reduced
- the client performs an isometric contraction of 20-30% maximum force and holds this for 6-8 seconds. The trainer should direct the client to begin slowly and progressively build the level of contraction
- the client relaxes (this can be aided by a deep inhalation followed by an exhalation as the stretch is administered) while the trainer passively increases the ROM of the stretch (increase hip flexion) until tension is felt again
- this cycle is repeated 2-3 times, always finishing with a stretch and not a contraction
- the trainer slowly returns the limb to its normal position

By isometrically contracting the target muscle (hamstrings in the above example) against the trainer, the client will activate the GTOs in that muscle and stimulate an autogenic inhibition response. This will create the necessary level of relaxation in that muscle to allow it to be stretched.

Since, the technique is very hands on and necessitates the trainer and client communicating clearly to create a stretch, passive stretching using PIR provides an excellent medium for establishing a rapport with the client.

When to apply: PIR based techniques are best suited to the post-exercise period. This will allow the trainer to stretch out the muscles worked during the main session and provides a relaxing 'wind down' for the client after their exertions. A good passive stretching session, performed by a competent trainer really embodies the personal, one-to-one nature of personal training.

Safety issues: safety should always be a priority for both the client and the trainer. An awareness of body mechanics and posture are vital for the trainer throughout the PIR protocols, but particularly during the isometric contraction phase. Consequently, the trainer should plan carefully and communicate clearly and freely with the client.

Trainer safety: the trainer may be at risk of injury if they do not take care of themselves during the application of PIR. However, by paying attention to their body mechanics and posture, the risk of injury can be virtually eliminated. Some useful tips for the trainer include:

- if standing, pay close attention to the legs and feet. A wide stance should be used to maintain balance and stability, especially when resisting the isometric contraction of the client
- be conscious of keeping the spine lengthened, rather than flexing and collapsing in on yourself. This will reduce the stress imposed on the spine
- maintain a neutral lumbar spine. This will again reduce the stresses imposed on the back
- brace the abdominals to prevent overarching of the spine
- avoid unnecessary twisting or bending. Instead, the trainer should try and get the client to move to accommodate them
- always try to use the trunk rather than the arms to resist the client's isometric contractions. For instance, during the hamstring stretch the trainer should block the client's contraction with their shoulder rather than the arm
- always control the strength of the client's contraction. The client should be instructed to "slowly build" the level of the contraction
- remain in control at all times. For instance, the client should only contract the target muscles on the trainer's instruction. In this way, the trainer will be able to prepare, and stabilise themselves effectively

Client safety: the client should be encouraged to play an active role in the application of PIR techniques. They should be encouraged to develop an awareness of the muscles being targeted. Clients should also provide as much feedback as possible; this might include what they are feeling during PIR stretches or their levels of fatigue. To ensure safety clients must:

- ask the trainer to stop if they experience pain at anytime. If the client does experience pain, the trainer should try repositioning the limb or ask the client to exert less force during the isometric contraction. If pain persists, do not continue until the cause of pain has been determined
- follow the trainers instruction at all times
- communicate freely with the trainer

When to stretch

Although always advocated after a warm up, stretching can be performed at any time of the day, appropriate to the client. Clients can be advised to stretch at home, watching TV, or at the office, in order to balance out periods of immobility in positions of poor posture.

Stretching should form an integral part of the warm up and cool down. Static stretching in the warm up has not been shown to decrease the incidence of injury, but may be selectively included in a 'corrective' form. An example of corrective static stretching would be to relax hypertonic pectorals when training the upper back (rhomboids and middle trapezius), for a more effective ROM during retraction. Corrective static stretching should only be used selectively on hypertonic muscles.

Dynamic stretching can be more easily prescribed as part of the warm up, using exercises that will mimic the general movement of the following session. Corrective static and dynamic stretches should be performed after some kind of pulse raising/ temperature rising warm up (Alter, 1998). In the post-training, cool down part of the session, some kind of static stretching is advised. This may be static maintenance, static developmental, or a form of PNF stretch.

Warm up	Cool down
Static stretching	Static stretching
Dynamic stretching	Developmental
Ballistic stretching	Muscle energy techniques (METs)

As well as setting specific and realistic flexibility goals, there are a number of guidelines an exercise specialist should follow for flexibility training (adapted and expanded from Alter, 1998; Fredette, 1998; and Holcomb, 2000):

Guidelines for flexibility training
• ensure correct position, posture and alignment prior to and during the stretch • take the stretch to a point of mild discomfort and do not strain or passively force a joint beyond its normal ROM • ensure correct breathing patterns are maintained and try to breathe calmly and rhythmically • exhalation during increases in ROM will aid whole body relaxation • closing the eyes, where applicable, may aid relaxation, focus and awareness • do not force a stretch whilst holding the breath • do not bounce or spring whilst statically stretching • wait until the stretch reflex has subsided, and the muscle has 'relaxed' before attempting to increase ROM during developmental stretches • unilateral stretches should be performed on both sides, where required • emphasise stretching the weight-bearing muscles and in particular, the multi-joint muscles • stretch towards the end of each workout as a minimal requirement, to prevent any unwanted adaptive shortening. The muscles should be very warm and receptive to extension, thus promoting recovery and relaxation • stretching in either a sitting or reclining position may aid relaxation for corrective and post-exercise stretching • concentrate and communicate when working with a partner • come out of a stretch as carefully as going into it

Alter (1998) suggests some additional guidelines when undertaking a stretching programme:

- wear loose, comfortable and appropriate clothing
- remove all jewellery and discard any chewing gum
- choose a clean, quiet place with a non-slip surface, preferably a firm mat

Following the guidelines above will be sufficient for most, but there are still a number of precautions when undertaking flexibility training (adapted and expanded from Fredette, 1998; and Holcomb, 2000).

Precautions for flexibility training

- decrease the stretch intensity or stop if the client experiences any local or radiating pain, or any loss of sensation
- any mild soreness following stretching should last no longer than 24 hours. If the soreness is prolonged, then the stretching was too aggressive
- use extreme caution when stretching any hypermobile joint, and question if developmental stretching is necessary
- avoid excessive or aggressive stretching of recently immobilised tissues (casting). These tissues can become dehydrated and lose tensile strength
- stretch with caution when working with any individuals with known or suspected osteoporosis (loss of bone integrity)

For most individuals, stretching will provide many of the benefits previously mentioned. However, there are certain individuals or groups for whom flexibility training may be likely to cause injury, or where the possible concerns outweigh the potential benefits. The table below lists the reasons why flexibility training (stretching) may be contraindicated (adapted from Alter, 1998; Fredette, 1998; and Minor and Kay, 1997).

Contraindications for flexibility training

- any developmental, excessive, uncontrolled or ballistic stretching should be avoided during pregnancy, due to the softening effects of relaxin
- if the movement is limited by a bony block
- avoid stretching a fracture site for approximately 8-12 weeks post-fracture
- any sharp pain occurring during a stretch
- any uncontrolled muscle cramping occurring during a stretch
- any infected joint or nearby tissue
- any acute inflammation, except for the majority of arthritic clients
- a local haematoma (bruise), resulting from an overstretch injury
- a client suffering with certain vascular or skin diseases

Student Task

Design and perform a cool down stretching routine using PIR techniques and suitable for use at the end of a general whole body muscular endurance workout.

Ensure the routine includes stretches for all major muscle groups. The routine also should provide a relaxing experience for a client.

Carefully consider the stretch sequence. The stretches should flow logically and require minimal unnecessary movement from the client.

Stretch	Muscle group(s)

References

ACSM News Release, (2004). *"Talk Test" A Consistent Gauge of Exercise Intensity.* http://www.acsm.org/publications/newsreleases2004/talktest090704.htm, 8/11/05

Alter, M.J. (1998). *Sport Stretch*, 2nd Edition. Human Kinetics

Bergman, R.A., Afifi, A.K. and Miyauchi, R. (2004). *Numerical Variation in Vertebral Column.* http://www.vh.org/adult/provider/anatomy/AnatomicVariants/SkeletalSystem/Text/NumericalVariation.html, 15/11/05

Borg, G. (1998). *Borg's Perceived Exertion and Pain Scales*. Human Kinetics

Bowers, R.W., and Fox, E.L. (1988). *Sports Physiology,* 3rd Edition. Dubuque, IA: William C. Brown

Chaitow. L. (2003). *Muscle Energy Techniques*, 2nd Edition. Elsevier Science

Chek. P. (2004). *How to Eat, Move and be Healthy.* San Diego, CA. Chek Institute.

Condon, S.M. and Hutton, R.S. (1987). Soleus muscle electromyographic activity and ankle dorsiflexion range of motion during four stretching procedures. *Physical Therapy,* **60**, 24-30

Conley, M. (2000). Bioenergetics of exercise and training. In *Essentials of strength training and conditioning* (T.R. Baechle and R.W. Earle, eds.). pp.73-90, Human Kinetics

Cotton, R.T. (1997). Testing and Evaluation. In ACE *Personal Trainer Manual* (R. T. Cotton, ed.) pp. 170-205, Ace Publishing

deVries, H.A. (1974). *Physiology of Exercise for Physical Education and Athletics.* Brown

Earle, R.W. and Baechle, T.R. (2004). NSCA's: *Essentials of Personal Training.* Human Kinetics

Elphinston, J. and Pook, P. (1999) The Core Workout - *A Definitive Guide to Swiss Ball Training for Athletes, Coaches and Fitness Professionals.* The Core Workout

Franklin, B.A. (2000). *ACSM's guidelines for exercise testing and prescription,* 6th Edition. Williams and Wilkins

Fredette, D.M. (1998). Exercise Recommendations for Flexibility and Range of Motion, In *ACSM's Resource Manual for Guidelines for Testing and Prescription* (J. L. Roitman ed.). pp. 456-465. 3rd Edition. Williams and Wilkins

Getchell, B. (1979). *Physical Fitness: A Way of Life.* Wiley

Gracovetsky, S.A., Farfan, H.F. and Helleur, C. (1985) The abdominal mechanism. *Spine*, 10, 317-24.

Granata, K.P. and Marras, W.S. (2000). Cost-benefit of muscle co-contraction in protecting against spinal instability. *Spine*, **25**(11), 1398-1404

Gray. H (2003). *The Complete Gray's Anatomy,* 16th Edition. East Molesey. Senate

Hodges, P.W. (2001). Changes in motor planning or feed forward postural responses of the trunk muscles in low back pain. *Experimental Brain Research*, **1441**(2), 261-266

Hodges, P.W., Moseley, G.L., Gabrielsson, A. and Gandevia, S.C. (2003). Experimental muscle pain changes feedforward postural responses of the trunk muscles. *Experimental Brain Research,* **151** (2), 262-71

Jones, D.A. and Round, J.M. (1990). *Skeletal muscle in health and disease. Manchester.* Manchester University Press

Holcomb, W.R. (2000). Stretching and Warm-Up. In *Essentials of strength training and conditioning* (Baechle, T.R. and Earle, R.W. eds.). pp. 321-342. Human Kinetics

Iashvili, A.V. (1983). Active and passive flexibility in athletes specializing in different sports. *Soviet Sports Review,* **18** (1), 30-32

Kabat, H. (1958). Proprioceptive Facilitation in Therapeutic Exercises. In *Therapeutic Exercises* (Licht, M. ed.). pp. 150-164. Waverly Press

Kendall, F.P., McCreary, E.K. and Provance, P.G. (1993). *Muscles Testing and Function,* 4th Edition. Lippinncott Williams & Wilkins

Kreamer, W.J. and Gomez, A.L. (2001). *Establishing a Solid Fitness Base In High-Performance Sports Conditioning* (Foran, B. ed.). pp. 3-18. Human Kinetics

Kreider, R.B. (1998). Creatine supplementation: analysis of ergogenic value, medical safety, and concerns. *Journal for Exercise Physiologists,* **1** (1)

Leighton, J.R. (1964). A Study of the Effect of Progressive Weight Training on Flexibility. *J. Assoc. Phys. Ment. Rehab*., **18**, 101

Lee, D. (2001). An Integrated Model of Joint function and its Clinical Application. http://dianelee.ca/published/4thCongressPaper.doc, 16/11/5

McArdle, W., Katch, F. and Katch, V. (2001). *Exercise Physiology: Energy, Nutrition & Human Performance,* 5th Edition. Baltimore, Lipincott, Williams & Wilkins

McGill, S (2002). *Low Back Disorders: evidenced – based prevention and rehabilitation. Champagn,* IL. Human Kinetics

Meyers, T.W. (2001). *Anatomy Trains.* London. Churchill Livingstone

Minor, M.A. and Kay, D.R. (1997). Arthritis. In ACSM's *Exercise Management for Persons with Chronic Diseases and Disabilities* (Durstine, J. L. ed.). pp. 149-152. Human Kinetics

National Institute of Arthritis and Musculoskeletal and Skin Diseases (2005). What People Recovering from Alcoholism Need to Know About Osteoporosis http://www.niams.nih.gov/bone/hi/osteoporosis_alcohol.htm, 16/11/05

National Institutes of Health, National Heart, Lung and Blood Institute (1997). Sixth Report of the Joint Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNCVI). *Public Health Service,* NIH Publication No. 98-4080

National Institutes of Health, National Heart, Lung and Blood Institute (2003). Seventh Report of the Joint Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC 7). *Public Health Service,* NIH Publication No. 03-5233

Norris, M.N. (2000). *Back Stability.* Human Kinetics

Panjabi, M.M., Abumi, K., Duranceau, J. and Oxland, T. (1989). Spinal stability and intersegmental muscle forces. A biomechanical model. *Spine*, **14**, 194-200

Panjabi, M.M. (1992). The stabilizing system of the spine. Part 1 Function, dysfunction, adaptation, and enhancement. *Journal of Spinal Disorders,* **5**, 383-89

Prentice, W.E. (1988). *Rehabilitation Techniques in Sports Medicine*, 2nd Edition. Mosby

Richardson, C.A., Jull, G.A., Hodges, P.W. and Hides, J. (1999). *Therapeutic Exercise for Spinal Stabilisation in Low Back Pain – Scientific basis and clinical approach.* Churchill Livingston

Robergs, R. A., Ghiasvand, F. and Parke, D. (2004). Biochemistry of exercise-induced metabolic acidosis. *American Journal of Physiology,* Regulatory Integrative and Comparative Physiology, **287**, 502-516

Schmidt R.A. and Wrisberg, C.A. (2000). *Motor Learning and Performance*, 2nd Edition. Champagn, IL. Human Kinetics

Shultz. R.L. and Feitis R. (1996). *The Endless Web*. Berkley, California. North Atlantic Books

Stone, R.J. & Stone, J.A. (2006). *Atlas of Skeletal Muscles,* 5th Edition. New York. McGraw-Hill

Tortora, G.J. and Grabowski, S.R. (1996). *Principles of Anatomy & Physiology,* 8th Edition. New York, Haper-Collins

Tortora, G.J. and Grabobowski, S. (2002). *Principles of Anatomy and Physiology.* 10th Edition. John Wiley and Sons

Twomey, L.T. and Taylor, J.R. (1987). *Lumbar posture, movement and mechanics: Physical Therapy of the Low Back*. New York. Churchill and Livingstone

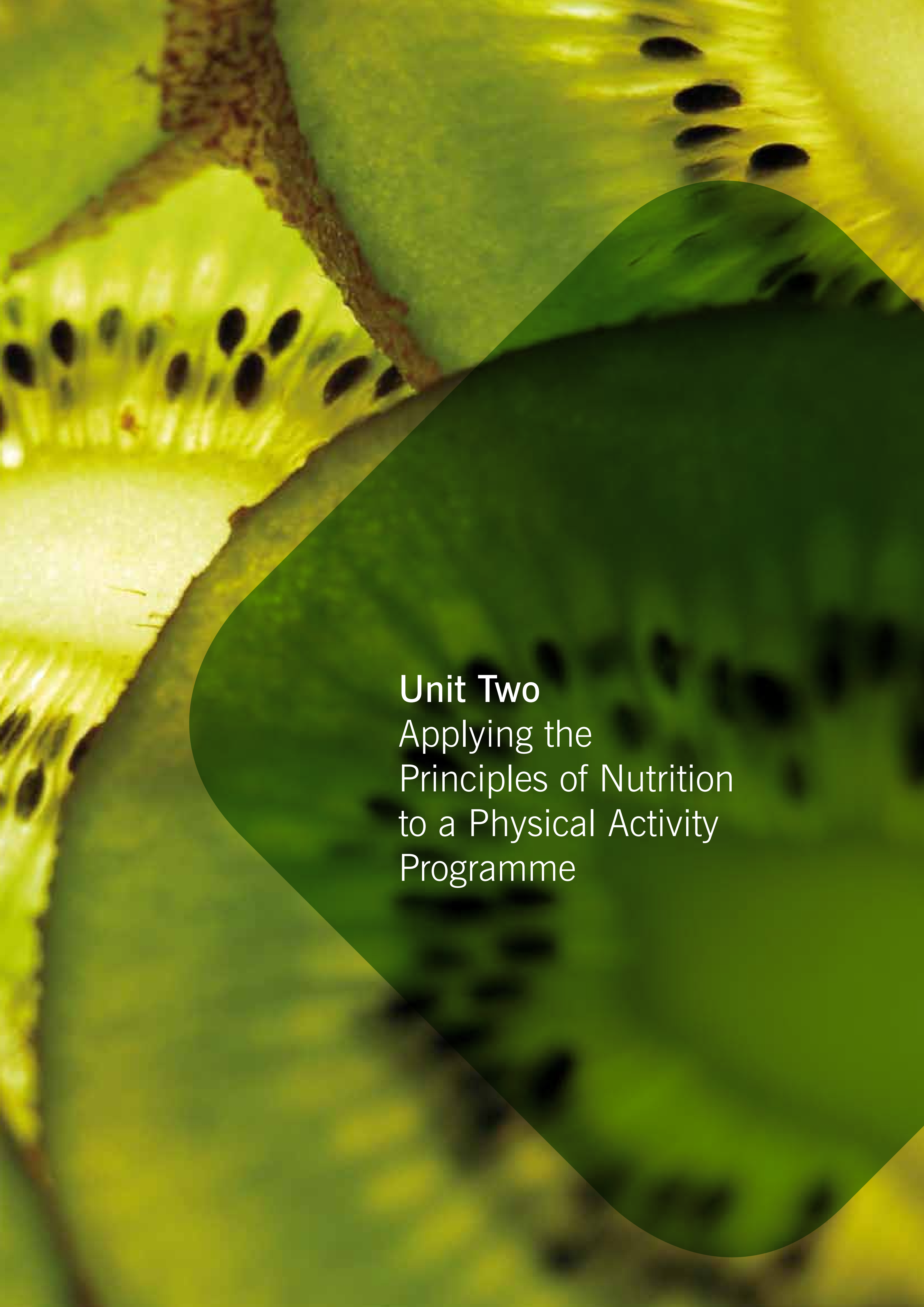
Wear, C. (1963). Relationships of flexibility measurements to length of body segments. Research Quarterly, **34**, 234-238

Weltman, A. (1995). *The Blood Lactate Response to Exercise* (Current Issues in Exercise Science). Europe, Human Kinetics

Wilmore, J.H. and Costill, D.L. (2004). *Physiology of Sport and Exercise.* Champaign, Ill., Human Kinetics

Wilmore et al. (1978). Physiological Alterations Consequent to Circuit Weight Training. *Med. Sci. Sports,* **10**, 79-84

World Health Organisation (2002). *The World Health Report 2002*. chapter 4., p5. http://www.who.int/whr/2002/chapter4/en/index4.html



Unit Two

Applying the Principles of Nutrition to a Physical Activity Programme

Applying the Principles of Nutrition to a Physical Activity Programme

Aim: to provide the learner with the knowledge and ability to apply the principles of nutrition to support client goals as part of an exercise and physical activity programme.

Learning outcomes

At the end of this unit the learner will:

- understand the principles of nutrition
- understand key guidelines in relation to nutrition
- understand nationally recommended practise in relation to providing nutritional support
- understand the relationship between nutrition and physical activity
- understand how to collect information in relating to nutrition
- understand how to use nutritional information
- understand the principles of nutritional goal setting with clients
- be able to collect and analyse nutritional information
- be able to apply the principles of nutrition to a physical activity programme

Introduction to nutrition

The human body requires energy to maintain life and health. It must have the means to grow from childhood through to adulthood, and to repair itself on a daily basis throughout life. In order to achieve this feat, oxygen, food and water are required. This course will examine the importance played by food and water in order to promote both good health, and effective training outcomes.

It is widely accepted today that in order to be healthy people need to eat a 'healthy balanced diet.' Yet despite this widely accepted principle it is difficult to determine exactly what this is. Healthy eating can be defined as food intake that promotes the correct and optimal operation of the structures and systems of the human body. The word balance suggests that foods of all different types are eaten in certain amounts and levels that keep the body operating, ideally, close to optimal level.

The word diet has become synonymous with cutting back, restriction and deprivation of food in order to affect physical change. However, diet is in fact, food intake and habits that are current for any individual. We all have a diet, but our food intake can vary considerably and, therefore, may not necessarily be healthy and balanced or providing adequate nutrients. The remainder of this unit will strive to describe the components found within food that provide nutrients for health and the levels needed to optimise health.

Nutrient groups

A balanced diet requires adequate water intake, alongside food chosen in varying amounts from five nutrient groups. These groups are in turn are divided into macronutrients and micronutrients.

Macronutrients	Basic functions
• carbohydrate • protein • fat	Collectively needed in greater amounts. Used within the body for structure, function and fuel. Note: alcohol also provides fuel, but is not classed as a nutrient.
Macronutrients	**Basic functions**
• vitamins • minerals	Needed in smaller amounts. Also used for structure and function and are necessary to "unlock" the energy contained in the macronutrients.

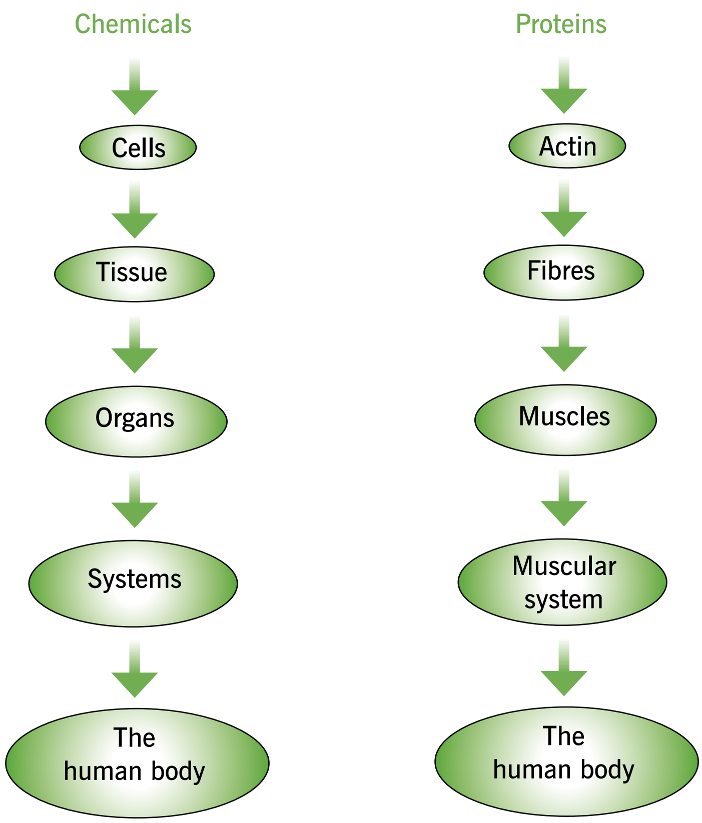
During subsequent chapters, the various nutrient groups and their individual and collective effects upon the body will be examined. The purpose of this chapter is, however, to introduce the relationship between the quality of the food in the diet, and the overall health of the individual.

The food that we eat will become part of the body, as it is used to rebuild or repair vital structures on an ongoing basis. So the phrase 'you are what you eat' has much truth in it. However, we do not digest everything that we eat as some components of our food will be excreted. So more correctly 'you are what you eat, but don't excrete.' Food, which is not used for this building up of structural parts of the body, will either contribute to the body's normal chemical functions, or be utilised as fuel to sustain life and activity levels. A continual excess of energy consumed will be stored, mostly in the form of body fat, and will therefore, also contribute to eventual body mass.

The organisation of life

Throughout the human body, a relationship exists between both structure and function, indeed it can be said that structure dictates function. This point remains central even to nutrition, whereby the quality of food within the diet and the specific chemical composition of that food, have a profound effect upon the structure and function of the human body at its most fundamental level.

To understand this point, it is necessary to examine the basic organisation of the human body, and an example using protein:



Other systems to which this same organisation applies are the:

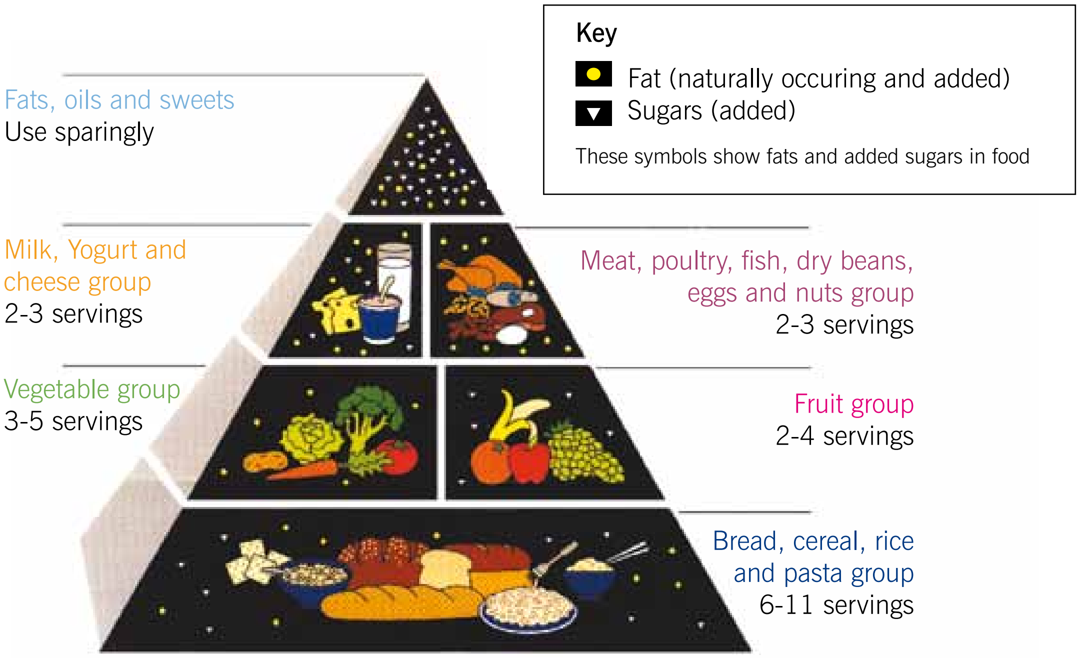
- skeletal system
- muscular system
- nervous system
- digestive system
- respiratory system
- circulatory system
- lymphatic system
- endocrine system
- reproductive system

National food and nutrition guidelines

The US national food guide pyramid was introduced in 1992 in an attempt to provide information to the public, in order to promote a healthy diet. It serves as a visual guide to ease the confusion that often arises when trying to plan a menu. Originally devised in a joint venture by the Department for Health and Human Services and the US Department of Agriculture (USDA), this basic model and the guidelines it represents has been adopted by many government agencies throughout the developed world.

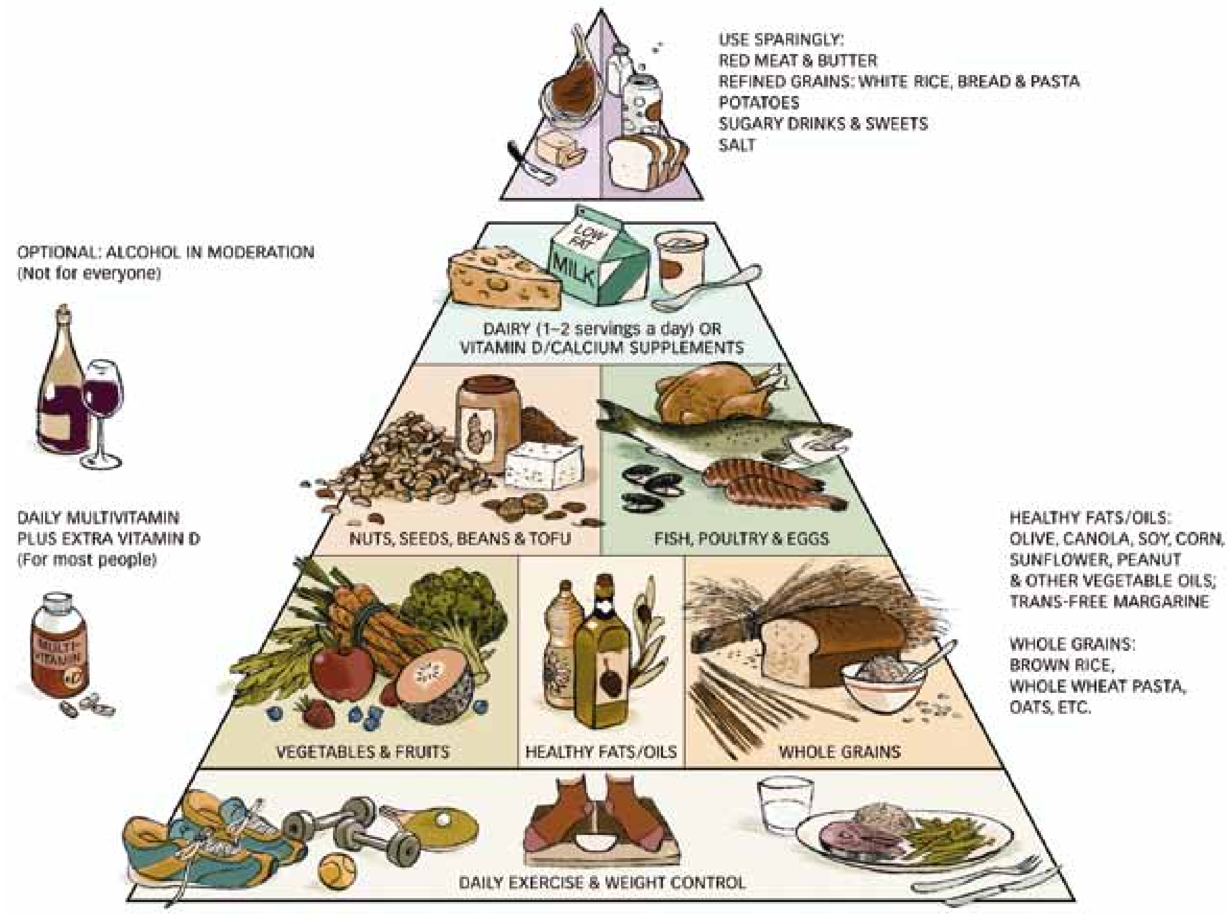
Now widely accepted, the USDA pyramid does have its critics (McCullough et al, 2000), however, it still serves to encourage people to think more carefully about the food they choose within their diet.

1992 National Food Guide Pyramid



The food guide pyramid was later revised due to continuing criticism that it did not provide appropriate advice for certain nutrient groups for all sub-groups of the population. In 2004, after much debate and deliberation the Department for Health and Human Services and the US Department of Agriculture released an updated version which was accepted as national policy in 2005. This has since formed the backbone of all food and nutrition policy throughout the United States.

The 2005 US National Food Pyramid



The revised pyramid finally responded to years of pressure that not all fats should be used sparingly, but that some fats should be taken in larger amounts as a necessary part of a 'healthy balanced diet.' Certain plant oils, such as olive, soy, sunflower and peanut oil are now set at the base of the pyramid and are advised as an important part of almost every meal. The advice on carbohydrates has also changed, recognising that refined carbohydrate products such as white bread, white rice and white pasta should be minimised. The emphasis is now on wholegrain carbohydrate rich products which form a large part of the base of the pyramid. These are certainly welcome improvements to the previous government advice, but the guidance still has some limitations.

The Food Pyramid	
Advantages	**Limitations**
• aims to encourage people to think about their diet • leads to a reduction in pre-made processed food • encourages consumption of fruit and vegetables • encourages portion control • aims to encourage a wholefood diet • encourages a moderate alcohol intake	• aimed at populations not individuals • assumes a 'one size fits all' approach • criticised for being shaped by food agencies and politics • insufficient guidance on portion control

UK national food guidelines

In the UK we have adapted the original food pyramid and underpinning guidance to follow what is called 'The Eatwell Plate' instead. This simple guidance model in its current form was introduced in 2007, though earlier versions existed prior to this. It provides an alternative illustration of the similar basic guidelines around food and nutrition found within the US pyramid. Whilst the illustration itself is very simplistic and provides less descriptive guidance than the pyramid, the guideline documents behind the national model provide some more directed advice.

‘The Eatwell Plate’ is also supported by 8 specific healthy eating tips as stated by the Foods Standards Agency:

1. Base your meals on starchy foods
2. Eat lots of fruit and vegetables (5 portions per day)
3. Eat more fish (2 portions a week, 1 oily)
4. Cut down on saturated fat and sugar
5. Try to eat less salt, no more than 6g a day
6. Get active and try to be a healthy weight
7. Drink plenty of water (6-8 glasses per day)
8. Don’t skip breakfast

The specifics of the national food model provide the following targets:

Adult males:	2550 calories per day
Adult females:	1950 calories per day

The total amount of calories should be divided across each of the macronutrients to achieve the following ratios:

- minimum of 50% calories from carbohydrates
- maximum of 35% calories from fats
- minimum of 55g of protein per day (9-12% calories)

The different macronutrients contain calories and useable energy. The values vary slightly, but are usually referred to with the following approximate figures:

• carbohydrates	4 calories per gram
• proteins	4 calories per gram
• fats	9 calories per gram
• alcohol (not a nutrient)	7 calories per gram

In trying to eat according to the national guidelines some may find incessant calorie counting a challenge and may prefer instead to guide themselves less intensely by following the suggested portion sizes. The following table provides some guidelines as to what counts as a typical portion. Please note that manufacturers can vary what they call a ‘portion’ in their favour to ensure their label information fits better with current nutrition trends. Be sure to read labels carefully. Later in the unit we will investigate food labelling more fully.

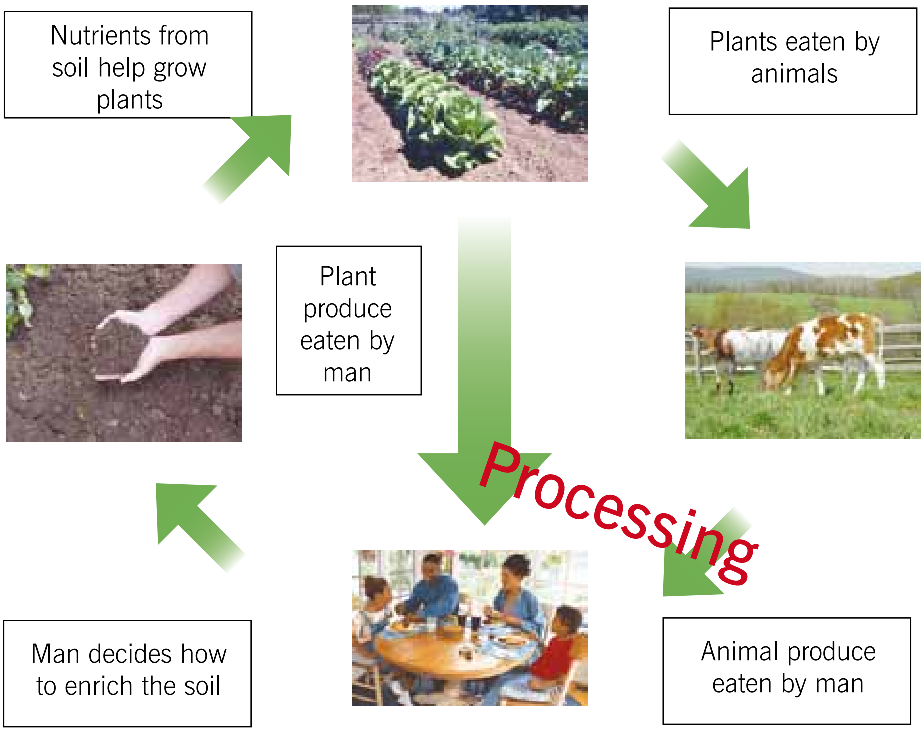
Food group	Portion guide
Fruit	Small fruit – 2 satsumas, 2 plums, 2 kiwi, 7 strawberries, 14 cherries Medium fruit – 1 apple, 1 banana, 1 pear, 1 orange Large fruit – half grapefruit, one 5cm slice of melon, 1 large slice of pineapple Dried fruit – about 30g, one large heaped tablespoon of raisins or sultanas, handful of banana chips Fruit juice – 150ml glass of unsweetened juice
Vegetables	Green veg – 2 broccoli spears, 4 heaped table spoons of kale, spinach, or green beans Salad veg – 3 sticks of celery, 5cm piece of cucumber, 1 medium tomato, 7 cherry tomatoes Cooked veg – 3 heaped tablespoons carrots, peas, corn or cauliflower
Bread, rice, pasta and potatoes	1 slice of bread Handful of rice or pasta Handful of breakfast cereal 1 small to medium potato
Meat, fish, eggs and beans	Lean meat the size of a deck of cards 1 large egg Side of fish the size of a standard chequebook Handful of beans, nuts or seeds
Milk and dairy	Small cup of milk 150ml of yoghurt Piece of cheese size of small matchbox
Food and drinks high in fat or sugar	Limit these foods to no more than 8% of total intake

Food quality

It must be recognised that while encouraging the eating of whole foods as stipulated by some of the current national guidelines, there are still factors that affect the quality of even fresh produce. Beyond food being refined, such as white flour being worse than brown flour, there is little other focus on the topic of what makes good quality food as identified within the national guidelines. This is a very important area as it determines the overall nutrient content of the food we eat at the table.

There are often many stages of handling, farming, manufacturing and preparation between when a seed is planted and a food is eaten. These can all affect the final product that will be eaten by man and therefore the nutrient levels found within. It is also possible to learn how to select good quality food as part of our shopping, but then cook and prepare food in such a way as we lose nutritional value before it is eaten. Therefore, it is necessary to understand how best to cook and prepare food to optimise the available nutrients within the food so they are more easily accessible to us. Unfortunately, cooking and food preparation methods go beyond the scope of this course, but should be encouraged in order to improve nutritional value.

The following 'Cycle of Food Quality' helps to identify some of the issues and concerns regarding our food production cycle:



Organic food

The organic farming movement began in the 1940's and has grown and developed into a highly marketable force. Organic produce is governed by strict regulations that help to maintain a higher standard of farming. One study found that in 85% of cases organic produce was shown to have an equal or higher nutrient content than commercial food stuffs (Worthington, 1999). The Soil Association checks approximately 70% of all organic producers in the UK are meeting the requirements laid down by European law. The Soil Association states that some of the key reasons for purchasing organic are:

- minimal use of additives
- no pesticides, fungicides or herbicides used in production
- no genetically modified foods used
- no routine antibiotic use on animals
- animal welfare is paramount

Nutrition and health

In an era when vast sums of money are spent on health care it is important that all avenues are investigated in understanding how to achieve optimal health and how to manage ill health when it appears. There is no doubt that the food we eat and physical activity, or lack of it, plays a significant role in both preventing and managing health problems. The following list of commonly occurring, modern day health complications and diseases have all been shown to have a root cause or risk factor associated with food and diet.

- obesity
- heart disease
- stroke
- some cancers
- metabolic syndrome
- diabetes
- hypertension
- high cholesterol
- asthma
- some types of arthritis
- menstrual irregularities
- infertility
- eczema

This unit will allow the trainer to advise normal healthy individuals to improve their nutrition. Where a qualified trainer is faced with more serious diseases and ill health beyond their scope of practise, it is vital that they refer the client on to an appropriately qualified and registered dietician or nutritional therapist. These professionals will be able to analyse and test correctly to determine specific nutrient deficiencies and also prescribe food and supplementation accurately to overcome and promote optimal health.

In order to more fully understand the effect which nutrition exerts upon health, exercise and physical performance, it is necessary to examine the nutrient groups in turn, and to determine the varying ways in which they interact, both within the population and within the individual themselves.

The role of a 'nutritionist'

Nutrition is a wide and varied subject that has become a substantial area of science within its own right. Inevitably, as with most areas of science, this leads to the creation of many theories and debates over what the truth is in relation to specific nutritional factors and optimal health. There are many experts and professional bodies where nutritional information can be sourced.

The term 'Nutritionist' is an unprotected term which anyone who wishes to embark on a business of advising others on what to eat can use to their advantage. It doesn't guarantee to the client any specific level of qualification. However, this also does not mean that the individual is not skilled at their job. To be called a 'dietician' requires individuals to be registered with the Health Professions Council as the term is legally protected and requires certain qualifications. Most dieticians have a Bachelors or Masters degree and are qualified to translate scientific information about food into practical dietary advice. The British Dietetics Association is the professional body for dieticians and also serves as their trade union. Registered nutritionists are nutrition professionals who have met the criteria to become full members of the Nutrition Society, which requires a degree and a certain amount of evidence supporting professional practise. The term 'Nutritional Therapist' refers to individuals who have trained to cure and prevent ill health through nutrition. Whilst courses in nutritional therapy are not seen to be in the same depth as dietetics there is still significant effort required to qualify for this title.

The British Association of Applied Nutrition and Nutritional Therapy (BANT) oversee and evaluate nutritional therapists in the UK with the Nutritional Therapy Council regulating the industry. This course will allow you to use the term 'Nutritional Advisor' which clearly defines a role in advising others about healthy eating habits, but does not authorise any provision of advice directing others regarding ill health or in the use of dietary supplements to promote health or manage disease. It is important that even as a nutritional advisor that it is understood how to evaluate nutritional information and to be able to ensure that advise is given to others based on reliable evidence. This does not necessarily mean that we should only listen to the mainstream opinion or seek information only from well recognised professional bodies, but they are an obvious place to start. We have already mentioned a few professional organisations above who can provide a high standard of reliable nutritional information. Other recognised places to seek nutritional information include:

- Food Standards Agency
- Committee on Medical Aspects (COMA) of Food and Nutrition
- British Nutrition Foundation
- Institute of Optimal Nutrition
- scientific nutrition journals e.g. British Journal of Nutrition

These and other similar areas are likely to provide reliable, evidence-based information on the wide and varied subjects that are included within the umbrella of nutrition. This is vital as the media and food marketing often report on or make claims regarding certain foods or nutrients and their effects on health. This will influence client's beliefs and opinions regarding nutrition and as professionals we need to have a reliable source of information to determine the truth and debunk any myths that exist. Nutrition tends to be a world of diverse opinions and theories and as such needs to have professionals who can provide a grounded and evidence-based approach where knowledge has been proven.

It must also be taken into consideration that the United Kingdom and many other countries around the world have now become diverse cultural and ethnic melting pots. This adds to the complexity of providing nutritional advice. It is important to have some understanding of the food habits and traditions of any individual for whom a service is being provided whether they have clear English ancestry or they are from Asia, Africa, the Pacific, the Caribbean or South America. Religious practises can also affect the foods they are allowed to eat and the liquids they may be allowed to drink. These religious practises need to be respected and nutritional advice provided that is supportive of their personal decisions and their cultural heritage.

Developing skills as a nutritional advisor can sometimes be a daunting process, especially with the vast amount of knowledge and information available on the subject of nutrition. If faced with a client who requires a deeper level of analysis and investigation than qualifications provide a suitable referral procedure to a Registered Dietician or Nutritional Therapist should be followed so that they may receive the guidance that they need. This is good professional practise and should be encouraged wherever necessary. It may become evident during an initial nutrition consultation that a client has specific health conditions that would require assessment and guidance from a General Practitioner to then be managed through food and diet again by a Dietician. Nutritional advisors will not have the skill base or qualifications to professionally advise on nutrition relating to disease and ill health. The types of conditions that can be improved through appropriate nutritional guidance and, therefore, should be referred are:

- diabetes mellitus
- cardiovascular disease
- elevated cholesterol
- severe obesity
- cancer

Macronutrients

Protein

Proteins belong to a family of organic compounds, which serve many functions within the body. All proteins are made from building blocks called amino acids, which number 20 in total. These amino acids can be thought of as forming the protein alphabet, since they build proteins in a similar way as the various combinations of the 26 letters of the alphabet can be used to create individual words. Thus one protein will differ from another according to the number and sequence of its constituent amino acids.

Peptides

Animal and plant cells join amino acids together to form peptides. This process results in the formation of chains of amino acids of varying lengths, which eventually become proteins.

Peptides		
Two amino acids	Dipeptide	Di meaning two
Three amino acids	Tripeptide	Tri meaning three
4-9 amino acids	Oligopeptide	Oligo meaning few
10 or more amino acids	Polypeptide	Poly meaning many

Proteins themselves are formed when the chain of amino acids total 100 or more, or when two or more polypeptide chains combine and repeatedly fold together to form specific three-dimensional shapes. The shape or structure of a protein will dictate its function within the body.

Essential amino acids

Of the twenty amino acids, ***nine*** are considered to be essential to the daily diet because the body is unable to produce or synthesise them itself. Only when sufficient quantities have been ingested, are we able to synthesise the remaining non-essential amino acids.

Essential amino acids	
• phenylalanine • methionine • tryptophan • threonine • lysine	• isoleucine • leucine • valine • histidine

Conditionally essential amino acids

These are also present in many foods, but are not always required to be a part of the daily diet. So long as we successfully absorb sufficient amounts of the nine essential amino acids, the liver is able to synthesise the remaining eleven conditionally essential amino acids. At certain times in life and in certain population groups these amino acids must be supplied by the diet to ensure good health. An adequate intake of the conditionally essential amino acids will also help to spare valuable resources of essential amino acids.

Conditionally essential amino acids	
• glycine • alanine • tyrosine • serine • cysteine • proline	• isoleucine • leucine • valine • histidine

Complete proteins

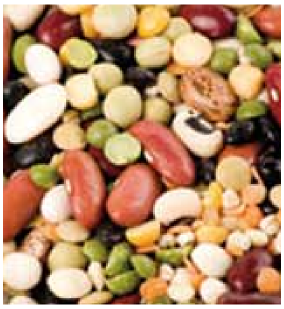
These foods contain all nine essential amino acids in sufficient amounts necessary for the liver to synthesise the remaining non-essential amino acids. Most are animal based foods, though some experts claim that there are a number of plant based complete proteins. Soy, buckwheat, and quinoa are some examples. However, it should be noted that soy, like all legumes, is deficient in methionine whilst fragile lysine is often damaged by processing.

Complete proteins	
Animal sources	Non-animal sources
• eggs • meat • poultry • dairy • fish	• soy foods • buckwheat • quinoa

Incomplete proteins

Plants contain many nutrients, including protein. However, these proteins are of a lower biological value, since they are deficent or 'incomplete' in one or more of the essential amino acids. Plants often contain smaller concentrations of protein thus making it difficult to ingest enough solely from plant produce.

Incomplete proteins
• cereals and grains (wheat, rye, barley, oats, rice) • cereal products (bread, pasta etc) • pulses (beans, lentils, peas) • nuts • vegetables



Complementary proteins

For many years it has been advised to vary or combine plant based protein sources to boost amino acid intake for vegetarians. This may help to provide a full spectrum of the essential amino acids in the diet.

Whilst these carbohydrate based foods contain energy in the form of glucose, it is important to remember that they also contain smaller amounts of protein. Including a variety of unrefined carbohydrate foods is, therefore, particularly important for anyone on a no meat or low meat diet. Good variations or combinations include:

- rice and pulses
- vegetables and seeds
- nuts and vegetables
- grains and pulses

Functions of protein

The types of protein within the body can be placed under three headings, along with their corresponding functions:

- structural: form the main framework of many components of the body; collagen present in bone and connective tissue, keratin in the skin, and muscle tissue all provide structure. Muscle tissue is also contractile for movement.

- homeostatic: hormones regulate various processes e.g. insulin controls blood sugar, enzymes speed up reactions, and white blood cells fight infection.

- fuel: although not the primary source, protein is a useable source of energy, especially during endurance events or periods of fasting. They can be converted into glucose, fatty acids or ketones to help produce ATP.

Catabolism

Catabolism relates to the breaking down of larger structures into smaller ones. Protein catabolism occurs to some extent all of the time, as existing proteins from damaged cells are broken down into their amino acids and recycled to build new proteins elsewhere. Further muscle catabolism occurs during intensive exercise, as a result of both micro-tear damage and the partial utilisation of key amino acids as fuel.

Anabolism

Anabolism can be defined as a building up process within the body. The anabolic phase mostly occurs during rest. Since proteins form a major component of most cell structures, adequate dietary protein is required to maintain both health and performance.

Protein requirements

The amount of protein needed for effective function will vary significantly from person to person. It is very difficult to get it right with a simple calculation. It will certainly take some trial and error and 'fine tuning' to find what works best for an individual. In the UK, it is very common to find the general public lacking in this vital nutritent. Commonly, the only decent amount of protein eaten during the day may be at the evening meal. It should be a major part of every meal consumed. A basic starting point is to consider the amount of protein needed dependent on body weight and the intensity of physical activity. The table below provides some suggested intakes set by the ACSM of grams of protein per day dependent on an individuals activity type and levels.

Daily protein requirements: grams of protein per kilogram body mass	
• sedentary adult	0.8
• recreational adult exerciser	0.8-1.5
• adult endurance athlete	1.2-1.6
• growing teenage athlete	1.5-2.0
• adult building muscle mass	1.5-1.7
• estimated upper limit; adults	2.0

Carbohydrates

Dietary carbohydrate (CHO) is digested and utilised in the body in a variety of ways. It is ultimately sent to the liver, muscles, or used immediately as a fuel. Some glucose may enter the adipose tissue (fat tissue), where it is used to help store fat, a process which appears to occur at different rates in different people (McDevitt, 2001). Carbohydrates are often thought of as the primary source of energy in the human body. This is not completely true as this really depends on what the body is doing at the time. Under normal daily activities both carbohydrates and fats contribute significantly to energy requirements, but as intensity of activity increases the contribution from fats diminishes and carbohydrates increases.

Structure

All carbohydrates are made up of molecules or units called saccharides. There are three basic categories:

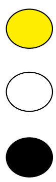
- simple carbohydrates also referred to as 'sugar'
- complex carbohydrates also referred to as 'starches'
- non-starch polysaccharides (NSP) referred to as 'fibre'

Simple carbohydrates

Simple carbohydrates have a very basic structure and usually only contain one or two units of sugar usually made up from a combination of glucose, fructose and galactose.

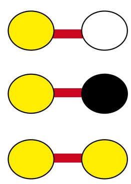
Monosaccharides – single molecules or 'units' of sugars e.g.

Glucose
Fructose
Galactose



Disaccharides – two molecules or 'units' of sugars joined together e.g.

Sucrose = glucose + fructose
Lactose = glucose + galactose
Maltose = glucose + glucose



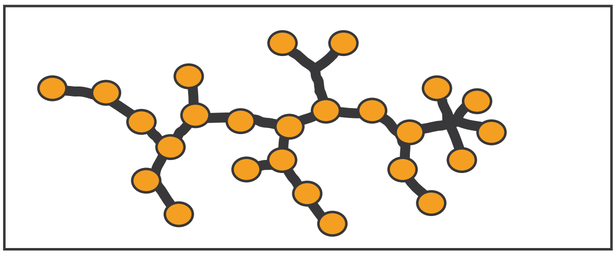
(ACSM)

Sources of simple carbohydrate	
Fruit: a healthy choice	Less healthy options: biscuits, cakes, confectionery, soft drinks
• contains fructose and glucose in varying amounts • contains vitamins and minerals • contains antioxidants and phyto-chemicals • contains high levels of dietary fibre • contains trace of amino acids • cheap, convenient	• contain excessive sugar – higher than 15g per 100g (FSA) • contains processed, low quality fats • high energy density • contain no vitamins or minerals • adversely affects insulin response

The energy contained in these foods cannot be released without specific vitamins and minerals. The B vitamins are particularly important, since we cannot utilise any carbohydrate without them. Fresh fruit provides its own vitamin and mineral requirements for the body. Heavily refined and processed foods still provide us with energy but without needed vitamins. Prolonged use of refined carbohydrates can lead to a progressive depletion of certain nutrients. This type of food is often referred to as an 'anti-nutrient'.

Complex carbohydrate

These foods are often described as starch and consist of many molecules or 'units' of glucose all joined together in long complicated branched chains. These multiple molecules of glucose are called polysaccharides.



Once eaten, these polysaccharides are broken down into glucose, absorbed into the bloodstream and either stored or metabolised accordingly. All such carbohydrates will provide energy. However, their real dietary value centres on whether they are refined or unrefined.

Sources of refined carbohydrate	Sources of unrefined carbohydrate
• white bread • white pasta • cakes, biscuits and pastries • rice cakes • CHO content of processed foods • white rice	• wholemeal or whole grain products • whole grain rice • frozen vegetables • fresh vegetables • sweet potatoes • yams • pulses • quinoa
Properties	**Properties**
• contains fructose and glucose in varying amounts • contains vitamins and minerals • contains antioxidants and phytochemicals • contains high levels of dietary fibre • contains trace of amino acids • cheap, convenient	• contain excessive sugar – higher than 15g per 100g (FSA) • contains processed, low quality fats • high energy density • contain no vitamins or minerals • adversely affects insulin response

Fibre

Fibre consists of non-starch polysaccharide (NSP), indigestible plant material such as cellulose, hemicellulose, lignin, pectin, gums and mucilages. These are found in fruits, vegetables, grains and beans. Fibre doesn't provide any energy, yet some scientists believe it is vital for a healthy body. It aids it the transportation of foods through the digestive tract by bulking out the food and faeces for ease of movement. There are two kinds:

Insoluble

It is normally the outer protective layer of plants. Unrefined wheat, bran, rye, rice and most other grains are primarily composed of insoluble fibre along with fruit and vegetable skins (Englyst, 1982).

Soluble

It is normally found on the inner part of plants. Found in beans, barley, broccoli, prunes, apples, citrus fruits and oats. This has been proposed to help with the reduction in cholesterol by binding with fats in the digestive tract and carrying them out in the stools.

Lipids or fats

Fats and oils belong to a family of organic compounds called lipids, and the role they play throughout human physiology makes them an essential component to the diet, and indeed they form one of the recognised macronutrients.

The aim of this chapter is to classify the most common dietary lipids, and to give an overview of their structure and function, and thereby provide a firm foundation for further reading. At present dietary recommendations for lipids, and their subsequent effect on human health, is the subject of great debate. Clearly, the role played by lipids within the body cannot be under estimated.

Key physiological functions of lipids
• formation of virtually all cell membranes • formation of myelin sheath within the nervous system • constitutes majority of the CNS and spinal cord • synthesis of steroid hormones • assists in the regulation of enzymes • insulation through subcutaneous adipose tissue • protection of internal organs • transportation, storage and utilisation of fat soluble vitamins A, D, E, K. • fuel source during lower intensity work loads • storage of energy within the adipose tissue

The structure of lipids

At room temperature lipids which are liquid are called oils, and those which are solid are called fats.

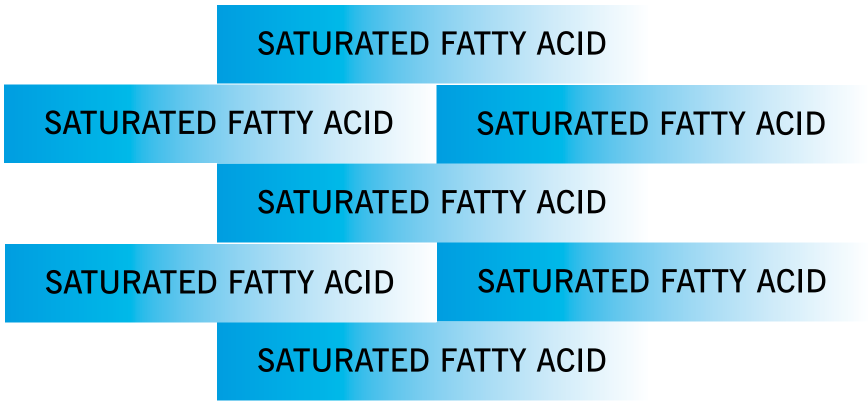
Most dietary lipids consist of chains or rings of carbon atoms joined together along with other atoms, most commonly hydrogen and oxygen. There are many different kinds of fats that vary mainly due to their structure. The smaller units of fats are called fatty acids. These are seen in differing molecular lengths and with the presence of double strength bonds between some carbon atoms. The double bonds change the shape of the molecule and enable lipids to become very versatile. A different shape means a different function in the body.

Triglycerides

Fatty acids naturally occur as triglycerides, where three fatty acids attach to a carbohydrate backbone called glycerol. During digestion the fatty acids are broken off and then used in the body as required.

Saturated fat

These fats comprise of chains of carbon atoms which are 'saturated' or full with hydrogen, which gives them distinct properties. They do not contain any double bonds which means they have a straight structure. The shape of fatty acids is highly significant in understanding both their resultant properties and the way they function within the body. Saturated fatty acids are straight, which accounts for their solid structure at room temperature, since they are able to pack tightly together with little space between them.



Common sources of saturated fat	
Animal	**Non-animal**
• meat – beef, pork, lamb, venison • poultry – chicken, duck • dairy – milk, cheese, yoghurt, cream, butter • eggs	• palm oil • coconut oil

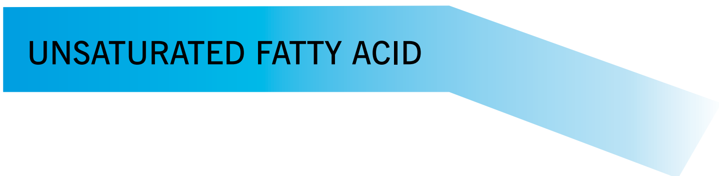
Research reveals there are specific needs for saturated fat to be included within the daily diet despite the common negative assumptions regarding this vital nutrient. These various functions include:

- enhancement of the immune system (Cohen, 1986)
- provision of energy and structural integrity to the cells (Mead et al, 1986)
- enhancement of liver function and protection against alcohol detoxification (Nanji et al, 1995; Cha and Sachan, 1994)
- the ability of coconut oil to act as an antimicrobal and antiviral agent (Projan et al, 1994;Hornung et al, 1994)

Unsaturated oils

These fatty acids are described as unsaturated because some hydrogen atoms are absent from the chain of carbons. This causes two effects:

- a double bond is formed between one or more of the carbon atoms
- the fatty acid bends at each double bond



Remember a different shape means a different function within the body. Unsaturated fats come in two main categories:

- monounsaturated – a single double bond – single bend in molecule
- polyunsaturated – several double bonds – several bends in molecule

Monounsaturated fatty acids: these oils contain fatty acids with only one double bond thus the term 'mono' or one. This means the molecule has a single bend in it. The body is able to recognise the distinct shape and length of the various monounsaturated fatty acids, and utilise them accordingly. Diets high in monounsaturated fats have been shown to lower both LDL cholesterol and plasma triglycerides, and are therefore thought to reduce the risk of CHD (Kris-Etherton et al, 1999). The body's tissues are also able to synthesise monounsaturated fatty acids from saturated fatty acids where necessary.

Sources of monounsaturated fatty acids	
• olives or olive oil • lard • beef dripping • peanut oil	• rapeseed oil • avocados • nuts • seeds

Polyunsaturated fatty acids: these fatty acids are long chains of carbon atoms, again with missing hydrogen but this time they posses more than one double bond. As with the monounsaturated fatty acids, there is a distinct bend at the point of each double bond, which again means a different shape and a different function.

Polyunsaturates have 2 sub-divisions which are considered essential to the daily diet.

Essential fatty acids: these fatty acids are essential to the diet since the human body is unable to synthesise them itself. They are sub-divided into two categories:

- omega 3 fatty acids
- omega 6 fatty acids

These fatty acids are very specific to the functioning of the cell, and must be eaten in the required amounts to promote good health.

Omega 3 fatty acids	Omega 6 fatty acids
• oily fish • flax oil • walnuts • pasture reared eggs Note: all oils need to be cold pressed and remain unprocessed	• sunflower seeds • sunflower oil • safflower oil • pumpkin seeds • sesame seeds Note: all oils need to be cold pressed and remain unprocessed

Omega 3 fatty acids found in oily fish are particularly beneficial. They have been shown to reduce the tendency of blood to clot, lower blood triglyceride levels, lower total cholesterol levels and in some individuals to raise HDL cholesterol, all of which are thought to lower the risk of CHD (Harris, 1989).

Hydrogenation and trans fats

This refers to a process used within the food industry where quantities of unsaturated vegetable oils are manufactured into more solid fats like margarine and shortening.

The heating, catalysing and pumping of hydrogen into unsaturated oils results in the formation of saturated fatty acids, as the original double bonds are broken and replaced with single bonds once again full of hydrogen. The amount of hydrogen added during the process will determine the amount of saturated fatty acids in the end product. The consistency of the final product will also be determined by the degree of hydrogenation. Fully hydrogenated vegetable oil would result in a very hard waxy substance. Most hydrogenation is partial, leaving varying amounts of the vegetable oil still containing unsaturated double bonds. Many of these double bonds however, will have been converted into trans fatty acids due to the actions of this intense and prolonged process. Trans fatty acids are detrimental to our health and warrant some explanation.

Hydrogenation plant

Common foods which contain trans fats	
• many margarine's • biscuits • cakes • crackers • take away foods	• pies • pastries • pre-prepared foods • many "low fat" processed foods (low in saturated fat but high in trans fat)

Consumption of hydrogenated fats is associated with a host of other serious diseases, not only cancer but also atherosclerosis, diabetes, obesity, immune system dysfunction, low-birth-weight babies, birth defects, decreased visual acuity, sterility, difficulty in lactation and problems with bones and tendons (Enig, 1995).

Metabolic studies have shown that dietary trans fatty acids have adverse effects on blood lipid levels, promoting an increase in LDL or 'bad' cholesterol, and a decrease in healthier HDL cholesterol, and that this effect is double that produced from the ingestion of saturated fat (Mensink and Katan, 1990).

Based on available metabolic studies, one report estimated that approximately 30,000 premature coronary heart disease deaths annually could be attributed to the consumption of trans fatty acids (Willett and Ascherio, 1994).

Cholesterol

Cholesterol is a large lipid molecule, which cannot be utilised by the body as energy; effectively it has no calories. However, it is extensively used throughout the tissues for both structure and functions essential to life. The functions of cholesterol include:

- a vital component of cell membranes
- production of steroid hormones
- synthesis of bile acids
- synthesis of vitamin D

Dietary cholesterol only plays a relatively minor role in meeting our daily needs. Cholesterol is so essential to life that the liver is able to synthesise about 75-80% of the body's own supply. When dietary cholesterol intake is low, the body increases the synthesis of its own supply, and as dietary intake increases cholesterol production falls.

Lipoproteins: cholesterol is a lipid, which means that it does not mix with the watery medium of blood. The body has developed protein-based carriers, called lipoproteins that completely encase lipids for transport in the blood.

Three key lipoproteins are:

- very low density lipoproteins (VLDL). Synthesised by the liver. Contain both cholesterol and triglycerides. Transport triglycerides into adipose tissue.

- low density lipoproteins (LDL). Formed from VLDL's once they have unloaded most of their triglycerides. Transport the remaining cholesterol to cells throughout the body that are in need.

- high density lipoproteins (HDL). Synthesised by the liver. Transport excess cholesterol from the tissues and blood back to the liver.

Measuring the level of cholesterol in the blood has become a key risk factor and marker in the pathology of cardiovascular disease. Particularly elevated levels of total triglycerides, elevated LDL cholesterol and lower than 25% HDL cholesterol has been identified as increasing the risk of heart and circulatory problems. In the UK the level identified in the mid 1980's as the desirable upper limit was a total cholesterol level of 5.2mmol/dL. Levels found above this will initiate the medical profession to intervene with lifestyle changes and in many cases medications such as statins to lower plasma cholesterol.

Food recommendations

Avoid	Advise
• low quality meats • battery farmed eggs • UHT or processed dairy products • meat pies, pre-packed meals • overcooking meats • white sugar, syrups • white flour, rice, white bread, pastries, cakes, biscuits • sweets and confectionery • soft drinks, cordial, cheap fruit juices • margarines, hydrogenated or partially hydrogenated fats • cheap plant oils esp. rapeseed, soybean, corn, sunflower and low cal oil spray	• fresh, quality fish, poultry and meat, ideally organic • organ meats – liver, kidney • organic free range eggs • organic, whole non-homogenised milk and dairy • slow cook at lower temperatures • wholegrain products • fresh, whole fruit and vegetables • home baking – know ingredients • organic butter, lard, goose fat, olive oil, coconut oil and flaxseed oil (flax should never be heated) • organic seeds – linseed, pumpkin • balance EFA's 1:1-2

Micronutrients

Vitamins and minerals form the micronutrients in the diet. Although we need these substances in much smaller amounts than the macronutrients (CHO, protein and fats), they remain a vital part of our diet if we are to maintain our health.

Vitamins

Vitamins also come under the category of micronutrients and consist of a group of organic compounds (all containing carbon), which are required for normal growth and metabolism. All vitamins are synthesised by plants and can be obtained in the diet by either eating the appropriate plants themselves or by eating animal products that have derived their vitamin content from plants.

We are capable of synthesising some of the B vitamins e.g. biotin and riboflavin, and vitamin K ourselves, from the action of bacteria found within our GI tract. Our bodies are also capable of assembling small amounts of certain vitamins from precursors called pro-vitamins often referred to as 'inactive vitamins'. For example, beta-carotene is a pro-vitamin found in yellow and dark green vegetables from which our bodies in the right circumstances may synthesise vitamin A. However, it should be noted that this is a difficult process for the body to undertake and an individual will not get any where near their daily vitamin A requirements by relying on the conversion of beta-carotene.

Fat soluble vitamins

Vitamins A, D, E, and K are termed as fat soluble, meaning that they can only be absorbed, transported and utilised in the presence of fat. A diet that is low in fat will lead to a severe deficiency in the fat-soluble vitamins, which will lead to ill health. For example, in the chapter on lipids we learned that cholesterol is the mother of all hormones. Several reactions need to take place to produce these vital hormonal chemicals. Each step of these vital reactions requires the action of vitamin A. Any deficiency in vitamin A will, therefore, affect the bodies' capacity to produce necessary hormones like testosterone, oestrogen and cortisol.

Water soluble vitamins

The B group of vitamins and vitamin C are all water-soluble and are absorbed, transported and utilised within water. They are all absorbed along the length of the digestive tract and tend to have an effect within the cells themselves. These vitamins cannot be stored within the body in any great quantity and therefore, we need to include them daily in our diet if we are to avoid an eventual deficiency resulting in ill health. A diet high in refined simple carbohydrates containing an excess of sucrose will eventually lead to such a deficiency.

The table opposite provides an overview of the functions and sources of some of the major vitamins or vitamin complexes.

Vitamin	Purposes	Sources
	Fat soluble	
Vitamin A	• stimulates gastric juices for protein digestion • plays vital role in bone building • helps produce rich blood • helps in RNA production • protects against pollution and degenerative damage	• butter from grass fed cows • pastured whole eggs • liver • seafood • cod liver oil
Vitamin D	• needed for calcium and phosphorus absorption • helps form strong bones and teeth • appears to protect against cancer and multiple sclerosis	• butter from grass fed cows • pastured whole eggs • liver • seafood • cod liver oil
Vitamin E	• aids blood circulation • helps with tissue repair and healing • slows aging process • powerful antioxidant • together with certain trace minerals protects against cancer and CHD	• unrefined vegetable oils • butter • organ meats • whole grains • raw nuts and seeds • dark green leafy vegetables
Vitamin K	• important role in blood clotting • aids bone formation	• liver • pastured whole eggs • butter from grass fed cows • whole grains • dark green leafy vegetables
	Water soluble	
Vitamin B complex	• work to promote healthy nerves, skin, eyes, hair, liver and muscle tone • prevents fatigue • vital role in metabolism • helps produce cholesterol • helps maintain iron levels in blood • maintains fertility and normal growth	• whole unrefined grains • fresh fruit • fresh vegetables • raw nuts • legumes • seafood • organ meats
Vitamin C	• aids tissue growth and repair • strengthens capillary walls • supports lactation • supports adrenal gland function • vital for formation of collagen • helps in healing of wounds • powerful antioxidant	• fresh fruit • fresh vegetables • some organ meats

Minerals

Minerals are necessary for structure and for the normal regulation of metabolic, hormonal and nervous interactions within the body. In simple terms, they enable our bodies to function correctly on a daily basis. They do not provide energy themselves but may allow our bodies to 'unlock' the energy contained within our diet. Minerals form approximately 4% of our body mass, mostly within the skeletal system. Plants extract the minerals from the soil, which enables us in turn to ingest them, assuming we have a varied diet. Although most minerals are important to the body, there are seven macrominerals that are required in greater amounts.

Mineral	Purposes	Sources
Calcium	• bone growth • muscular contraction • regulates acid-alkali balance	• dairy products • fish with soft bones – salmon • green leafy vegetables
Chloride	• regulates acid-alkali balance • regulates fluid balance • aids protein/ carbohydrate digestion	• natural unprocessed sea salt • coconut flesh
Magnesium	• nerve transmission • bone formation • metabolism of carbohydrates • absorption of other minerals • tooth enamel	• natural unprocessed sea salt • fish • dairy produce • nuts
Phosphorus	• bone growth • kidney function • cell growth	• animal produce • whole grains • nuts and legumes
Potassium	• fluid balance • cellular chemistry	• natural unprocessed sea salt • nuts • vegetables
Sodium	• water balance • cellular fluid distribution • nerve stimulation	• natural unprocessed sea salt • meat broths • zucchini
Sulphur	• protects from infection • helps form cartilage and skin • protects against radiation and pollution	• cruciferous vegetables • eggs • dairy products

There are many other minerals found on the periodic table that are ingested alongside the foods that we eat. Many of these minerals are needed for a healthy functioning body, but are required in much smaller amounts than the macrominerals identified above. These are referred to as the trace minerals. There are over 20 minerals that have been acknowledged as essential for human health, many of trace minerals have been listed below.

Trace minerals	
• copper • manganese • iodine • boron • iron • nickel	• selenium • zinc • cobalt • chromium • molybdenum • silicon

Phytochemicals

These are chemicals synthesised by plants, which appear to have an important effect upon human health. There are many categories of phytochemicals to study and learn, much more than the scope of this unit will cover. A few of the main categories include:

- carotenes
- flavonoids
- isoflavones
- phytosterols

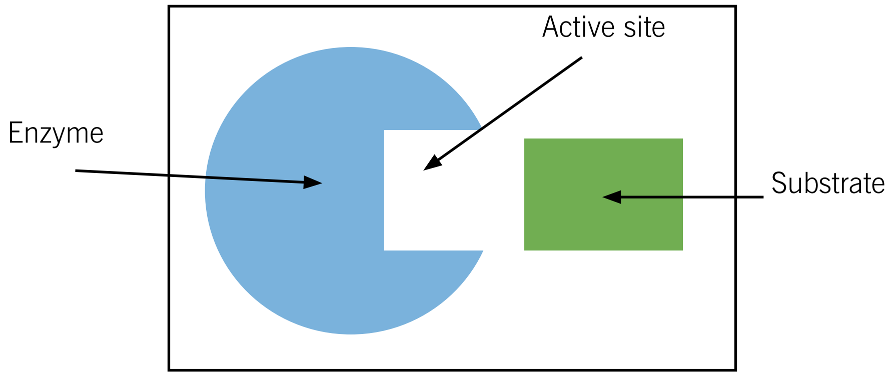
These types of plant nutrients have been found to benefit the human body in many different ways from cancer prevention, cholesterol management and in preventing oxidation and damage of structures.

Enzymes

For every physiological change in the body a specialised protein molecule known as an enzyme provides the stimulus. Its job is to catalyse or speed up chemical reactions within the cells so that the physiological changes that support life can take place more quickly. The rate a t which these reactions take place is totally dependent upon the enzyme, often increasing them by one hundred thousand to one million times.

How does an enzyme work?

An enzyme has a precise three-dimensional structure. By adjusting or altering the structure of the enzyme, the body can use it as a switch to turn on and off the reaction that it catalyses or other reactants involved in the process. These reactants that bind to the enzyme are known as substrates, and the point on which the substrate binds onto the enzyme itself is known as the active site. The two fit together almost like a lock and key, thus only an appropriately fitting substrate can bind to the specific enzyme. Once this binding process has taken place, it can now promote the desired reaction and cause the eventual outcome.



Each enzyme is specific for only one substrate. There is a 'one lock' and 'one key' principle, where the active site of the enzyme also has a unique fit for one specific substrate and no other.

Since this whole process relies on a unique fit between the substrate and the active site in the enzyme, it often requires assistance, which almost customises the substrate in order to achieve a perfect fit. This assistance comes from either co-enzymes, which are derivatives of vitamins, or co-factors, which are minerals. Therefore, vitamins and minerals play a vital role in helping enzymes to function appropriately and sustain life.

Antioxidants

As the human body evolved to utilise oxygen, it has also evolved elaborate defences in order to limit damage that can occur as a result of oxygen based reactions. These come in the form of antioxidant enzymes, which the body produces naturally within the cells, such as superoxide dismutase. Dietary antioxidants can also be acquired from the food that we eat. People with poor diets, depleted of nutrients, may be at greater risk, as the body's antioxidant enzymes require nutrients such as vitamins A, C, E and minerals including zinc, selenium, copper and manganese in order to function properly.

Antioxidants are substances that slow oxidative damage that happens within the human body. Both enzymes and the nutrients play a role in breaking the damaging chain reactions. Research suggests that regular exercisers do have a much higher level of their natural antioxidant enzymes to help protect them (Cardwell, 1999).

Sources of antioxidant nutrients	
• vitamin C – citrus fruits, green veg, peppers, tomatoes, potatoes • vitamin E – unrefined veg oils, egg yolks, whole grains, almonds, nuts, green leafy veg	• zinc – oysters, ginger root, lamb, nuts, grains, eggs, peas • selenium – grains, meats, fish, brazil nuts, tuna, shellfish, dairy

As we get older, we lose the battle against environmental damage from radiation, pollution and increasingly poor diets. Exercise also increases oxidative stress through increased oxygen consumption, so it is important to stress that those engaging in regular and especially intense exercise, need to ensure that their diet is better than the average to ensure high nutrient densities. A variety of vitamins and minerals from many different sources will ensure that the body can function nearer its optimal level. This should help limit any damage caused by exercise, including injuries, and to help promote recovery caused by myofibril damage (DOMS).

Micronutrient requirements

Nutrition Facts

Serving Size 1 ounce Servings in bag 4

Amount Per Serving			
Calories 165		**Calories from fat 93**	
			% Daily Value*
Total Fat 11g			**18%**
Saturated Fat 9g			**15%**
Trans Fat			
Cholesterol 0mg			**0%**
Sodium 148mg			**6%**
Total Carbohydrate 14g			**5%**
Dietary Fibre 1g			**5%**
Sugars 1g			
Protein 2g			
Vitamin A	**0%**	• **Vitamin C**	**9%**
Calcium	**1%**	• **Iron**	**9%**

***Percent Daily Values are based on a 2000 calorie diet. Your daily values may be higher or lower depending on your calorie needs**

There are several different nutrient reference tables used to provide guidance on the levels of vitamins and minerals required by the body. These are collectively known and labelled today as the Dietary Reference Values (DRV's). The DRV's basically provide estimated guidelines for the energy and nutrient needs of healthy people in the population, though they do not take into account exercise needs. Nutrient requirements in the UK have been estimated on the back of two reports. The first was by the Committee on Medical Aspects of Food and Nutrition (COMA) published in 1991 in a report called Dietary Reference Values for Food Energy and Nutrients for the United Kingdom. The second report which superceded some of the COMA information was by the Scientific Advisory Committee on Nutrition (SACN).

The British Nutrition Foundation states that 'DRV's are estimates of the requirements for groups of people and are not recommendations or goals for individuals. However, health conscious people who go out and shop for food will likely be relying on the DRV's for guidance on how they should eat as an individual. So it is questionable as to how relevant the values provided actually are. They are also only estimates based on 4 systems of estimated or average values of nutrients. Trainers and clients need to understand that these values are not going to provide any individualised nutrient guidance and will not ensure that they will be taking in adequate nutrition to support the growth, repair and energy expenditure during exercise as this has not been factored into any of the nutrient guidance.

Supplements are also advertised as containing 100% of the Recommended Daily Allowance (RDA). The RDA system of nutrient guidance was devised in the early 1950's as a general guideline to minimal intakes needed to prevent disease, not to optimise health. Even if the level of nutrient was 100% bio available, which is unlikely, it is still unlikely to provide adequate nutrition to support and exercising client to obtain optimal health. The RDA system is viewed today as a very dated nutrient reference system and has been superseded several times. The current system used to provide minimum nutrient requirements is called the Recommended Daily Intake (RDI). In many instances, the nutrients levels have increased in the RDI reference system in comparison to the old RDA system. However, these are still viewed as the nutrient levels needed to offset deficiency and disease.

There are a number of specific population groups who are more likely to experience nutritional deficiency and should be investigated more closely to ensure they are receiving enough nutrition for the needs. These groups include but are not limited to:

- children
- elderly
- pregnant and lactating women
- those with chronic disease conditions

Due to the increased demand on the body for growth, the wear and tear of life or the additional stress on the body caused by each of these circumstances the nutritional requirements may actually be much different than the typical recommended daily intakes. If you are unsure of the guidance to provide for anyone of these population groups then it would be appropriate to refer them to a registered dietician or nutritional therapist who will guide them as their needs require.

Vitamin and mineral supplementation

The area of supplementation is vast and fraught with many questions and considerations. This unit is not designed to cover this topic in any great depth and would certainly not provide a basis for a successful student to advise any client to take vitamin or mineral supplements. However, there are some key issues with regards to supplementation that need to be addressed for a broader understanding of this area.

Some supplements extract their nutrients from foods, such as vitamin A and D extracted from fish oils. Other supplements are made in laboratories which may be labelled as 'natural' because they are made from 'natural' precursors. Fat soluble vitamins A, D, E and K are best sourced from natural sources where they are present in fats, oils or oil capsules, rather than in tablets or pills..

Vitamin B-complex supplements only contain 8-12 of the different types of B vitamins despite the name 'complex' implying a full spectrum of nutrients. Individuals taking a 'complex' of B vitamins may assume they are getting all needed B vitamins, but this is simply not the case. Almost all vitamin C in supplements are made in a laboratory and are usually pharmaceutical grade ascorbic acid. However, vitamin C in natural foods comes as part of a complex including minerals; something called rutin and other analogs which help buffer the vitamin and increase bioavailability.

Minerals in food almost always exist in complexes with other substances and nutrients. Minerals in supplements are usually present in engineered complexes. The substances with which they are combined often affect the degree to which they are absorbed and utilised. Again, some mineral supplements may be extracted from foods whilst others are combined in a laboratory. The most commonly taken mineral supplement calcium is found in numerous forms, but only one of those forms is a natural food extract, calcium hydroxyapatite. The other forms of calcium supplementation may be combined with other substances that have a negative impact on the bioavailability of the nutrient.

Many people today believe they are covering their nutrient bases by taking a daily multivitamin. This is certainly not a fool proof way of getting the nutrients the body needs. These supplements are clearly lacking many of the natural types of nutrients such as all of the B, D, E and K vitamins.

A key point to understand is that supplements are only designed to support a nutrient rich diet, they are not a quick fix solution for a poor quality diet. However, carefully evaluated, high quality nutritional supplements can provide good support to health when taken in correct dosages under the direction of a suitably qualified registered nutritionist or dietician.

Food recommendations

Avoid	Advise
• limiting food choices • 'fresh' produce from overseas – picked unripe – lower nutrients • fortified foods – lack quality • processed fruit and vegetables • cooking at high temperatures • cheap or standard vitamin or mineral supplements	• eat variety of fresh fruit and vegetables • eat high quality animal produce • eat seasonal, local produce - freshest • eat raw fruit where possible • eat raw or lightly cooked vegetables • broaden tastes – try new foods

Digestion

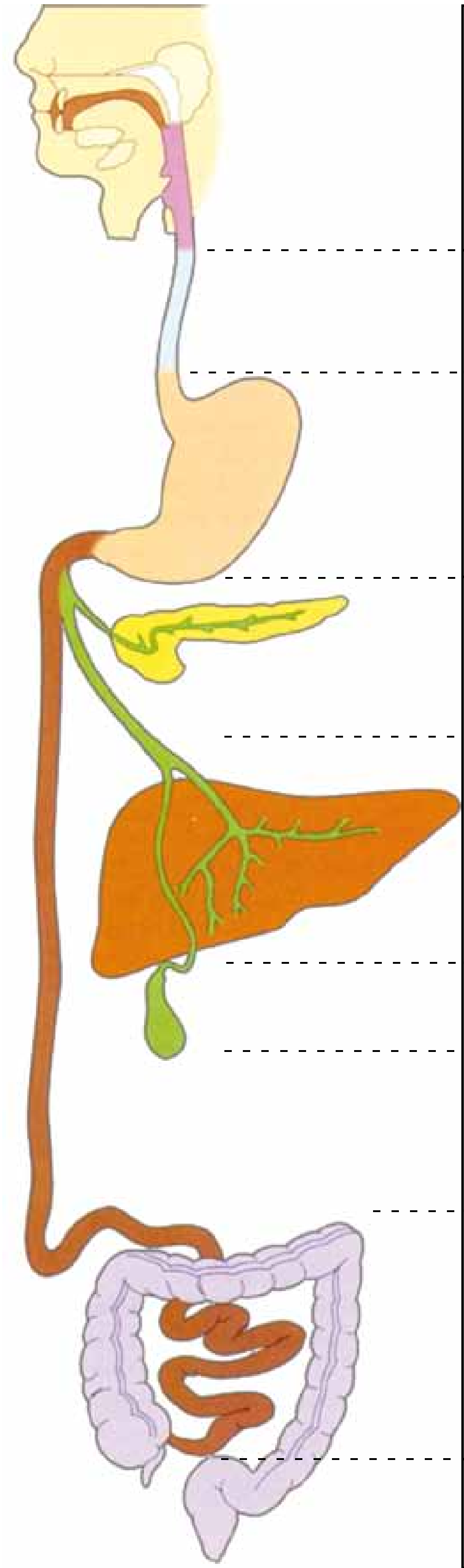
The digestive system can be seen as the body's own food-processing factory. It provides two critical functions: digestion and absorption of nutrients. The body is unable to absorb or use large food molecules and therefore has to break them down into smaller and more manageable units before they can be assimilated. This is the job of the digestive system and it fulfils this role through the combined efforts of chemical and mechanical digestion.

Many of the components of the digestive system secrete special substances called enzymes. Enzymes are chemical catalysts and speed up the digestive process by breaking down the large, unabsorbable macronutrient molecules into smaller, absorbable ones. The enzymes themselves are not changed in these reactions and just like a lock and key, each enzyme will only work on specific nutrients.

Digestion and absorption of all nutrients takes place within the gastrointestinal tract (GI tract). The GI tract is a hollow tube that runs from the mouth to the anus. The organs that make up the GI tract are the mouth, pharynx, oesophagus, stomach, small/large intestines and the anus. Each of these components fulfils a precise function.

Location	Enzyme	Nutrient
Mouth	Salivary amylase	Carbohydrates
Stomach	Pepsin	Proteins
Small intestine	Lipase	Fats
Small Intestine	Pancreatic amylase	Carbohydrates
Small intestine	Trypsin	Proteins

Macronutrient	End product
Carbohydrates	Glucose
Proteins	Amino acids
Fats	Free fatty acids, glycerol



Mouth:
Mastication – mechanical chewing

Saliva – moistens food, protects teeth against decay, contains an enzyme
Salivary amylase – begins to break down larger carbohydrate molecules

Oesophagus:

Peristalsis travels food down to the stomach

Stomach:
Gastric juices contain acid and enzymes
Hydrochloric acid – kills bacteria

Pepsin – breaks proteins into shorter chain peptides

Pancreas:
Pancreatic juices contain enzymes
Lipase – breaks fat into fatty acids
Amylase – CHO into glucose
Trypsin – proteins into amino acids

Liver:

Food doesn't pass through liver

Produces bile acids – emulsifies fats, or mixes fats with water

Gall Bladder:
A storage reservoir for bile acids

Small Intestine:
Main site of digestion and absorption
Pancreas and gall bladder empty into 1st section – duodenum villi absorbs nutrients into blood

Large Intestine:
Colon absorbs any remaining water, vitamins and minerals

Bacteria – produce some vitamins and fight infection in intestine

Rectum stores faeces

Anus:
Opening for elimination of waste

Food labelling

Learning to understand and grasp the basics of how to interpret food labels is an essential tool for anyone keen to improve their nutrition. In today's world, food manufacturers are required to place a lot of very useful information on their labels. This information is particularly helpful in making consumer shopping choices.

Nutrition label 'basics'

There are certain elements that must by law be placed on a food products label. The following illustration from a chicken soup tin identifies each area:

Supermarket brand chicken soup

Identifies macronutrient and calorie values

NUTRITION INFORMATION

TYPICAL VALUES (cooked as per instructions)

	per 1/2 CAN	per 100ml
ENERGY	472 kJ	236 kJ
	113 k cal	**57 k cal**
PROTEIN	**2.2g**	**1.1g**
CARBOHYDRATE	**9.0g**	**4.5g**
of which sugars	1.8g	0.9g
of which starch	less than 0.1g	less than 0.1g
FAT	**7.6g**	**3.8g**
of which saturates	1.6g	0.8g
FIBRE	**0.2g**	**0.1g**
SODIUM	**0.8g**	**0.4g**
per 1/2 CAN	**113 CALORIES**	**7.6g FAT**

Ingredients are listed in descending weight order

INGREDIENTS

WATER, RAPESEED OIL, MODIFIED MAIZE STARCH, CHICKEN (2%). WHEATFLOUR, CHICKEN FAT, SALT. SUGAR, FLAVOURINGS, DOUBLE CREAM, SKIMMED MILK POWDER, FLAVOUR ENHANCER: MONOSODIUM GLUTAMATE: EMULSIFIERS: TRISODIUM DIPHOSPHATE, SODIUM POLYPHOSPHATE, HYDROLYSED VEGETABLE PROTEIN, DEXTROSE, COLOUR: BETA CAROTENE; MUSTARD

***CONTAINS MILK & WHEAT**

(www.sainsburys.co.uk)

They must also include:

- manufacturers details
- a total volume or weight
- a date mark or best before date
- storage instructions
- potential allergens in the product

The nutritional information table provides average amounts of each macronutrient expected to be found in the product. However, a recent survey reported that out of 70 products tested for 570 nutrients only 7% actually matched the stated values, and almost one fifth contained levels outside of the generous 20% margin of error (BBC News, 2005). Although these tables do provide information, it is not guaranteed accurate and can be misleading.

Currently foods sold 'loose' or cooked 'in house' are not subject to many of the food labelling laws.

Food Standards Agency

The Food Standards Agency (FSA) set up on 3rd April 2000 is responsible for governing the control and sale of food in the UK. They are an independent body that helps in protecting public interests with regard to our food, and serve in an advisory role to promote food legislation. The law requires that they make public the information they generate and the advice they offer to government. Current food production, labelling, and manufacture are governed by the 1990 Food Safety Act. The FSA is charged with protecting consumer interests on both food safety and food standards. The FSA were responsible for the food model that guides both corporate and consumer alike, 'The Eatwell Plate.'

Marketing terminology

Food manufacturers use many different terms in their pursuit of selling their products to the public. This has almost certainly been brought about by the fierce competition in the food sales market. The FSA has provided many guidelines and legal requirements in the use of these terms so that they are not misleading to the public. However, once again research has found some manufacturers to be misusing certain terms to boost sales. The Foods Advisory Committee reported that up to 75% of consumers found terms like 'fresh', 'pure', and 'natural' to be misleading (Llewelyn et al, 2001). Below is a list of terms and how the food regulations state they should be used:

- fresh – 'to differentiate food sold a short time after harvest'
- pure – 'single ingredient foods…or to highlight the quality of ingredients of a food'
- natural – 'comprised of natural ingredients, not the work of man'
- authentic – 'remains unchanged…originates from the area implied by its name'
- home made – 'made in the home, or of domestic manufacture'
- traditional – 'a method of preparation that has existed for a significant period'
- farmhouse – 'other than bread, it should refer to that produced on a farm'
- original – 'a method of preparation that has remained essentially unchanged over time'

Many of these terms have relatively loose meanings that can be left purposely open to individual interpretation. How long is a short time after harvest? The word ‘pure’ seems to imply more than just a single ingredient. Somehow it makes it better. ‘Natural’ seems better because we don’t think of nature as being harmful. Plenty of plants and chemicals produced by both plants and animals can do us damage and make us sick. These would not be maliciously added to our foods, but be aware that natural ingredients can and are added to foods that may not maintain an optimal level of health. Traditional conjures up images of the very way in which a food or recipe was first made being handed down from parent to child. It could just mean the way the factory has made a product has been pretty similar since they first started selling it.

These common interpretations and images created by words more often than not (75% time according to above research) plays into the hands of the manufacturers in leading the consumer to believe it indicates something positive about the quality of the food that is 100% accurate when considering the legal definition. With an increasingly health conscious public many foods are targeted at this market and so the terminology used on packaging reflects this. But again this can be misleading if the public don’t understand the legal implications.

Healthy marketing terminology

The media have played a significant role over the last 20 years in making us acutely aware of the dangers that a poor lifestyle can have on our health. With an increasingly health conscious public, many foods are targeted at this market and so the terminology used on packaging reflects this. Manufacturers work hard on their labels to be sure foods that are meant to be healthy stand out to the consumer even more, so that they can grasp their cut of the sales in this enormous market niche. Many terms and phrases are used to increase appeal, such as ‘low in salt’, ‘low in fat’ and ‘sugar free’. These phrases directly link in to what most health conscious consumers have been taught to seek for in ‘better’ foods.

- ‘light, low, reduced or high’ – there are no specific guidelines for these terms, but they should not mislead
- ‘reduced or low fat’ – must be at least 25% lower in fat, but often calories are maintained by adding other ingredients
- ‘low calorie’ – must have lower calories than the original, but no set level
- ‘sugar free’ – sugar has not been added, but almost always an artificial sweetener has been used for taste

Food additives and labelling

Food manufacturers are required to list a large number of allowable food additives by either identifying its ‘E’ number or by its proper name. It is very common today to find manufacturers favour the use of technical names that the general public are ignorant of, rather than the use of E numbers, which the health conscious strive to avoid. It is important to start to take time to become familiar with the more common terms used so more informed decisions can be made when choosing food.

Refined sugars

In many cases, these sweetening compounds are mildly addictive, contain empty calories and help to increase sales. Commonly added sugars and caloric sweeteners are:

- sugar
- dextrose
- glucose syrup
- glucose-fructose syrup
- inverted sugar syrup
- high fructose corn starch
- mannitol
- xylitol
- sorbitol
- maltodextrin

Monosodium glutamate (MSG)

This is an isolated amino acid that acts as a flavour enhancer and has also been found to have addictive qualities. It has been linked with obesity due to its effects on the hypothalamic region of the brain and the net resulting influence on appetite. MSG (E621) is only required by law to be included on the ingredients list if it is added in its pure form. Free glutamic acid is still present in many other additives and is likely to still cause the same problems. Any of the following ingredients will indicate its presence:

- yeast extract
- hydrolysed protein
- whey protein isolate
- soy protein isolate
- carrageenan
- most 'natural' flavourings

Artificial sweeteners

Sweeteners are usually found in foods that are targeted towards the diet industry and when consumers want to reduce the number of calories that they are taking in. No calorie and low calorie sweeteners have answered this need for many people. All the major sweeteners used in the food industry are categorised by some experts as 'excitotoxins' that stimulate the sensory areas of the brain and potentially craving sensations and appetite. It is clearly an advantage to manufacturing companies to increase the sweetness of a product and add a mildly addictive compound that will lead, in the long run, to more being ingested and ultimately purchased. Almost all of the most commonly used sweeteners have been scientifically identified as having potentially harmful side effects. Whilst the reduction in calories to assist weight loss may be important, it is vital that the potential risks associated with consumption of these compounds is also understood.

- Aspartame (E951) is sold under other brand names such as NutraSweet, Equal and Spoonful. The American Food and Drug Administration have received more complaints about aspartame than any other additive in history. Aspartame has been linked with a number of health conditions such as high blood pressure, seizures, depression, numbness, aching muscles and dizziness. It is currently present in over 6000 food products available to the consumer.

- Sucralose (E955) is also sold under the brand name Splenda. Scientific tests have linked high intakes to shrinking of the thymus gland and enlargement of the liver and kidneys, reduced growth, decreased red blood cell count and diarrhoea.

- Acesulfame K (E950) stimulates insulin which causes hypoglycaemia when a response higher than is needed follows a low calorie intake.

- Saccharin (E954) has had a shaky history of approved and condemned status. It is currently listed as an 'anticipated human carcinogen' which in sensitive individuals may cause irritability, insomnia, headaches, itching or diarrhoea.

Additive categories

E100's – are colourings

E200's – are mostly preservatives

E300's – are antioxidants, acidity regulators and anti-caking agents

E400's – are emulsifiers, thickeners, stabilisers and gelling agents

E900's – are generally waxes, sugars and sweeteners

Other E numbers – anti-foaming agents, carrier solvents, bulking agents, firming agents, flavour enhancers, flour treatment agents, glazing agents, modified starches or raising agents.

Additive safety

The majority of additives on the officially accepted lists have been shown to be safe when kept within accepted limits:

- 150 additives have had concerns raised about them due to some signs of adverse reaction in testing
- 70 additives are known to cause allergic reactions and intolerance in some people
- 30 additives are known to be harmful (Millstone and Lang, 2004)

It is important to recognise that while food manufacturers may keep within the safe and accepted limits for the additives they use, some additives are prevalent in many products. This may mean that during the day or week we may consume more than is desirable due to the cumulative effect of ingesting many foods containing these additives. Aspartame, monosodium glutamate and saccharin are some of those additives that are rampant in the current food market.

Additives are a relatively new addition to the food chain, and ultimately should not be in our food, even if they have been found to be beneficial to the manufacture and sale of the product. We should try to minimise their presence in our diet. The guidelines are as follows:

Food recommendations

Avoid	Advise
• processed food in general • fast foods • confectionery • soft drinks and cordials • pre-packaged meals • refined baked goods • 'low fat' foods or 'healthy' options • cheap sausages, burgers, pies	• buy organic–additives used minimally • use whole, fresh produce • home baking – you choose ingredients • always read food ingredients lists

Exercise nutrition

The best nutritional recommendations to accompany an exercise regime will vary according to the physiological demands placed upon the body, and therefore must be relevant to specific training programmes.

Aerobic training requires fuel, which can be provided by fat, carbohydrate and even protein. Whilst working at lower intensities, a greater percentage of fat will be utilised for energy, but with rising intensity of exercise a progressively higher amount of carbohydrate will be drawn into the fuel equation.

The serious exerciser or the dedicated athlete is faced with an array of information and possible options to best suit their needs. These choices can be narrowed down to the following:

- the use of food alone
- the sole reliance on sports drinks and/or protein shakes
- a combination of food plus sports drinks
- a combination of food plus protein shakes
- a combination of food plus water

Fuelling aerobic and anaerobic sport

The main mantra over the last 20 - 30 years of sports nutrition has been to take in the right amount and type of carbohydrates to ensure the necessary amount of blood glucose is available for use by the aerobic and anaerobic energy systems to produce ATP (energy molecule) for muscular contraction. In simple terms, the aerobic system is able to utilise both fats and carbohydrates to fuel activity and the anaerobic (lactate) system uses only carbohydrate. The understanding is that the higher the exercise intensity the more anaerobic we become and so more carbohydrates are used. This is the reasoning why so much of the focus is placed on carbohydrates for sports fuel. The key question is whether the idea of high intensity exercise being purely anaerobic is correct. Science can provide some answers to this question:

- research into an elite 5 mile cross country run found that contrary to popular thought anaerobic work contributed to 58% of total work – '…results underline the importance of…the contribution of anaerobic systems to the success of cross country performance.' (Bulbulian, 1986)

- when the contribution of aerobic and anaerobic energy systems were investigated during short term exhaustive cycling it was determined that the aerobic system contributed 40% energy during a 30 second sprint, 50% of a 1 minute sprint and 65% of a 2 minute sprint. (Medbo, 1989)

A 2004 study found that the aerobic / anaerobic energy contribution split during 100m and 200m sprinting was as follows (Duffield, 2004):

Event	Gender	Aerobic	Anaerobic
100m	Male	21%	79%
	Female	25%	75%
200m	Male	28%	72%
	Female	33%	69%

It is clear from these three studies that both aerobic and anaerobic energy systems contribute to exercise regardless of the intensity, although it does appear to change the longer the duration. Therefore, it follows reasonable logic when considering aerobic cellular energy producing pathways that carbohydrates alone will not provide the best energy as fats will provide some contribution to optimal energy across the spectrum from long duration to sprint type events.

Pre-exercise meal - high or low glycaemic index?

It has often been quoted that a pre exercise meal is best chosen from low GI foods. The rationale for this belief is that, if a high GI carbohydrate meal is taken before training or competing, the relatively rapid rise in blood glucose will cause a corresponding release of insulin.

The feared effects of high GI CHO were:

- an increased rate of early glucose oxidation
- a 'rebound hypoglycaemia' effect where the increased insulin causes a rapid fall in glucose levels possibly even before the session has begun

The original research reported that cyclists given a low GI meal consisting of lentils eaten one hour before intensive exercise, performed for longer before fatiguing, when compared to those fed on a high GI meal. The researchers suggested that glycogen sparing may have occurred with the low glycaemic trial, thus promoting better performance. However, post training glycogen levels were never measured, and subsequent studies have failed to prove any clear benefit from pre-feeding on a low glycaemic meal.

The majority of studies show that there may be slightly more favourable metabolic conditions with regards to insulin levels during exercise associated with low GI foods than with high GI alternatives. But these differences are small and short lived. The conclusion is that athletes probably perform the same on both pre-race meals.

As will be discussed later, the real difference in performance appears to be related to carbohydrate feeding during exercise, which seems to over ride any metabolic or performance effects arising from the type of pre-event meal. Athletes should consume adequate amounts of carbohydrate drinks during endurance exercise, and may feel free to choose their pre-exercise meal according to their personal preferences.

Carbohydrate taken during exercise or competition

Different studies have indicated that ingesting carbohydrates is acceptable:

- if the session is longer than an hour
- if the match or race is longer than 90 minutes
- if a pre-exercise meal is not possible (such as early morning intensive training)

The consumption of isotonic drinks during exercise has been shown to delay the onset of fatigue and to improve performance in endurance athletes. Many athletes find it difficult to consume even a light meal before exercise without causing gastrointestinal discomfort, or they simply may not have time to eat before their planned training session. Often people have to train early in the morning, making a pre-exercise meal impossible. One study found that ingesting an isotonic drink during endurance training is as effective as a pre-training carbohydrate meal. The replacement of fluid provided by the isotonic drink is also a direct advantage.

Post-exercise meal guidelines

After intensive exercise, the muscles are more sensitive to the effects of insulin thus enabling a more efficient replacement of lost glycogen. This process is particularly evident during the first two hours following the training session. The rapid synthesis of muscle glycogen stores is aided by the immediate intake of high GI carbohydrate.

Why high glycaemic index CHO post-exercise?
• increased glucose availability • increased insulin • increased glucose uptake • increased glycogen synthesis

Some studies have advised the following guidelines
• post-training: 1 gram CHO per kilogram body mass every two hours (50 grams per meal) • first intake within 15 min post-training • intake over 24 hours: 7 –10 grams CHO per kilogram (500 –700 grams of CHO per day) *(Burke et al, 2000)*

The frequency of carbohydrate meals post-training does not appear to exert an effect on glycogen replenishment. Small regular intakes or three larger meals appear to gain the same results.

General exercise

This category refers to people under taking lower intensities of training, where a greater amount of fat will be utilised with some possible loss of glycogen. These guidelines are somewhat similar to normal guidelines for eating, except that it should be timed appropriately around the exercise session.

Guidelines for general exercise
• aim to stay within energy balance • create energy deficit of 250 kcal if trying to lose body fat • fulfil CHO needs, chose from moderate to low GI foods • try to provide energy that can be metabolised, don't mix high CHO with high fat • smaller portions and regular meals favour the oxidation of nutrients • micronutrients should be high • fibre should be adequate • include adequate protein • EFA's should be eaten in balance

What is an isotonic drink?

Sports drinks are now widely used in order to improve performance and recovery. They serve two main roles, notably the replacement of fluid and the provision of fuel in the form of carbohydrate. Isotonic drinks have a similar balance of dissolved solids to the blood. This helps provide a faster rate of absorption of fuel whilst maintaining reasonable hydration. They also contain the necessary electrolytes or salts lost through increased sweating during intensive exertion.

As previously stated there are several studies showing that the use of sports drinks has been beneficial in prolonging activity and has particularly helped as fuel replacement during exercise. However, it should be noted that many of the commercial sports drinks have other additives which are less desirable. It is not uncommon to find isotonic drinks that have sweeteners and colourings in them. Aspartame and acesulfame K are common sweeteners (see food additives chapter) and have undesirable side effects.

Another option is to make your own equivalent of a sports drink. Below are 2 options:

- dissolve 60g glucose into a litre of water and add a fifth teaspoon of natural unprocessed salt
- mix 500ml of unsweetened fruit juice with 500ml of water and add a fifth teaspoon of natural unprocessed salt (paralympics.org.uk)

Hydration

There are many complicating issues around the subject of hydration, especially as freely available modern drinks have become so wide and varied. The sugar, salt, caffeine and alcohol levels will all influence fluid balance in some way. Even food contributes somewhat to overall cellular hydration levels. The difficult guidance to give is how much water should be taken in order to ensure there are sufficient levels within the blood and cells to optimise function. Other additional factors that may change the levels of water needed include:

- environmental temperature
- amount of lean muscle mass
- frequency, intensity and type of exercise

All of these factors must be considered when determining the hydration needs of any individual. Several different health professionals recommend that water intake should be guided by drinking half of the body weight in pounds in fluid ounces of water e.g. a 150lb person should drink 75 fluid ounces of water. We do not typically work in pounds for body weight or in fluid ounces in the UK and so it would be more user friendly to convert these measures. This system is only intended to provide a basic guideline, but at least provides a starting point. The table below provides a summary of suggested water intakes for different body weights.

Body weight (kg)	Estimated daily water intake (litres)
55kg	1.70
60kg	1.85
65kg	2.00
70kg	2.15
75kg	2.30
80kg	2.45
85kg	2.60
90kg	2.75
95kg	2.90
100kg	3.05

Protein shakes

Protein shakes have become a popular training supplement in the last 20 years, partially due to the increased profile of bodybuilding, but also because of the significant investment in advertising in men's magazines and the internet. The appeal is a quick, easy to use supplement that enables individuals seeking hypertrophy to achieve their increased protein needs. Much of the advertising implies that their supplement is the 'answer' and is a 'highly advanced' or 'precision engineered' muscle building formula. So how much is marketing and how much is truth?

Whey protein is found in milk, which averages about 6.5% protein, of which about 20% is whey protein. In its natural state it has the highest biological value to the body of any protein, due to its high concentration of essential and branched chain amino acids. This makes it useful to the body in many ways, one of which is in the repair and growth of muscle tissues. However, by the time a tub of whey powder is purchased it is often vastly different from the original product. Consider the following points:

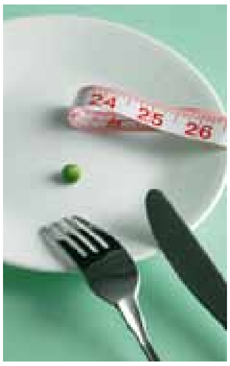
- whey is a waste liquid by-product from cheese manufacture. Traditionally it was disposed of by farmers into animal feeds
- often dried at high temperatures for speed of manufacture – above 60ºC these fragile proteins become denatured, which destroys their ability to function
- manufacturers use sugars, sweeteners, colours and flavours to improve palatability
- often very low in fat – proteins need fat for proper metabolism and use. Some studies indicate that skimmed milk can lead to increased body fat storage compared to whole milk
- often backed up by self-funded research, if any – this does not provide an independent, objective view
- prices now are highly inflated due to market demand generated by clever advertising

It is important to recognise that protein shakes were only intended to supplement, not replace good food. The body is designed to absorb and metabolise real, untainted food and protein sources. If a supplement is required then consider the following points before purchasing:

- seek cold processed protein powders, manufactured below 50 ^{o}C
- no added sugars, sweeteners, colours or flavours
- mix with whole organic milk, as fats are necessary for protein metabolism

Avoid	Advise
• commercial isotonic sports drinks • most commercial protein or meal replacement shakes • most cereal or 'health' food bars • low quality, refined carbohydrates • use of carbohydrates in isolation for energy • dehydration	• make your own isotonic drink if needed for energy • eat organic full fat animal produce to meet protein needs • eat organic raw nuts, seeds, fruit etc. for healthy snacks • allow time to eat proper meal rather than sacrificing for convenience • drink quality water as the body needs

Weight management



The goal of weight management is to prevent the accumulation of excess body fat and for those who are already overweight, to reduce body fat to an acceptably safe level in order to prevent the health risks associated with obesity (Robinson et al, 1995). The ultimate answer to successfully managing weight is eating according one's metabolism. Metabolism is dependent on many factors and variables which need to be understood in order to eat accordingly.

Popular diets

Many different dietary approaches are used today by all kinds of different people in their efforts to achieve a body weight and size they are happy with. It would be beneficial to overview the main approaches prior to embarking on a discussion of the main concerns surrounding weight management.

It is vital that client's who have embarked or are planning to embark on a diet like these understand the reasoning behind the approach and the potential health risks associated with these dietary and weight loss methods. Empathetic, accurate and clear communication will help the client make an informed decision.

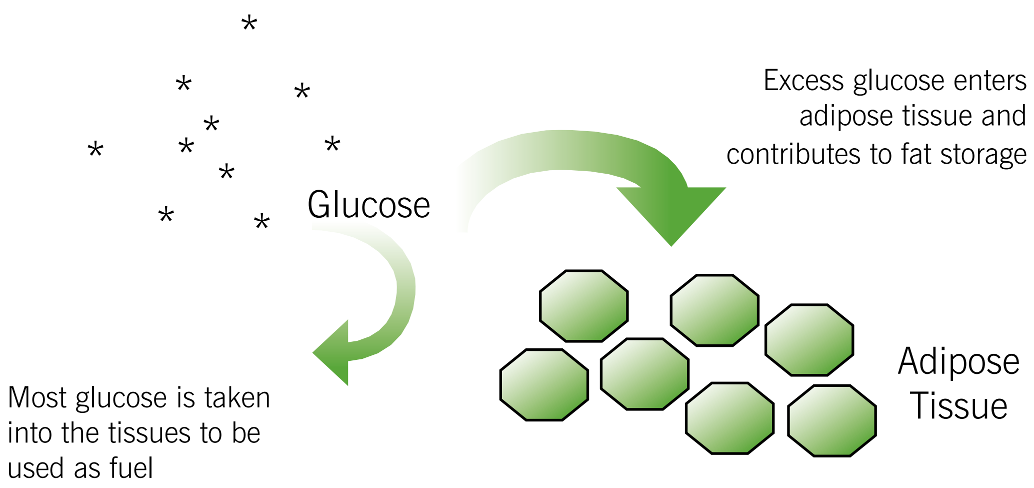
Dietary method	Reasoning	Problems
Fasting	• helps to detoxify many systems of body • creates negative energy balance – weight loss • rests the digestive system	• risk of dehydration • lack of essential nutrients • lack of energy • increased headaches, aches and pains, allergies and bad breath
Very low calorie	• doctor supervised replacement shakes and bars • often only 800 kcal/day • fortified with daily requirements of vitamins and minerals • designed for the obese to achieve rapid weight loss	• fatigue, constipation, nausea or diarrhoea • possible gall stone formation • low bioavailability of many of fortified nutrients • only a short term approach
Calorie counting groups	• group involvement creates accountability • calorie intake controlled • guidance of foods to eat provided	• tends to be a short term fix • 'yoyo' dieting cycle common • nutrient intake may be compromised
Meal replacement	• control the intake of food with calorie counted meals and shakes • usually 1200-1500 kcal • removes the complexity of calorie counting for consumer	• boredom and taste fatigue • lack of energy • low bioavailability of many of fortified nutrients • low adherence

Dietary method	Reasoning	Problems
Food combining	• CHO digest better in alkali environment • proteins digest better in acidic environment • foods should be separated and eaten at different times	• erratic blood sugar responses from high CHO to no CHO • very restrictive meals • may lack vitamin A, D, B12, zinc and calcium due to low animal intake
Fat-burning supplements	• create a thermogenic effect in body • boost the metabolism to burn body fat	• may cause illness – even heart attack, seizures and stroke • may cause arrhythmia • may cause depression, nervousness or insomnia

Adipose tissue

Adipose tissue consists of individual fat cells or adipocytes, which function to store excess dietary fat and energy in the form of triglycerides. Circulating lipoproteins serve as transport vehicles for lipids within the bloodstream. Lipoprotein lipase (LPL) acts on lipid containing lipoproteins sent out to the adipose tissue from the liver, causing them to unload triglycerides into adipocytes.

Adipose tissue is also capable of storing excess energy from an over consumption of carbohydrate. If excess carbohydrate is consumed over several consecutive days leading to a positive energy balance, the result will be an increase in body fat (Acheson et al, 1988). Glucose enters the adipose tissue where under the influence of insulin, it is synthesised into fat and stored as triglycerides. It is more likely when insulin levels are elevated.



Adipocytes may either increase in size, or under certain environmental conditions, increase in number. Either change will lead to a net increase in the amount of body fat on an individuals frame. Some scientists have theorised that overfeeding during childhood, especially puberty, may stimulate an increase in the number of total fat cells (Malina and Bouchard 1991). They claim that these fat cells remain for life and, therefore, increase the likelihood of obesity later in life. Other scientists have challenged this hypothesis, claiming that the original research that showed this relationship also demonstrated that the number of fat cells could be altered later in life as well. Correlations between infancy and adult obesity levels did not show a significant relationship (Roche, 1981).

Perhaps genetics do play a role in the total number of fat cells, but it is unlikely that this factor will predestine an individual to becoming obese. Environmental factors at any age will influence the fat storing capacity of those adipocytes.

Distribution of body fat

The distribution of adipose tissue also has some significance and is influenced by genetics, gender and hormonal dominance. An excess of central or abdominal fat is more common in males and may be referred to as an 'android' or 'apple' body shape. Central obesity is associated with insulin resistance (Helmrich et al, 1991), and with an increased risk of disease including coronary heart disease (Seidell et al, 89). Peripherally distributed fatness is more common with females and may be referred to as a 'gynoid' or 'pear' body shape. This shape represents less of a CHD risk factor, though may predispose the individual to other health concerns. Hormone dominance has been shown to play a role in how body fat is deposited. Understanding the different body shapes can help in knowing how to feed the body to encourage a better balance of the dominant hormonal controls.

There are several different methods commonly used and established in good practice for assessing body composition and determining health risks associated with both total weight and body shape.

- Body Mass Index (BMI)
- Abdominal Circumference
- Hip to Waist Ratio

Whilst each of these methods do not specifically measure body fatness they are relatively simple and have been clearly shown to provide valid markers for associated health risks.

BMI provides information on the amount of body weight found within each square metre of the body and is measured using kg/m^2. It is calculated by dividing body weight in kg by height in metres squared. The following table provides information on how to assess health risk based on BMI.

Classification of overweight and obesity by Body Mass Index (BMI)		
	Obesity class	BMI (kg/m^2)
Underweight		<18.5
Normal **Acceptable**		18.5 – 24.9
Overweight **Special Attention**		25 – 29.9
Obesity **Medical Referral**	I	30 – 34.9
Severe obesity	II	35 – 39.9
Morbid obesity	III	>40

(National Institute of Health, 1998)

Fat stored in the abdominal region (as opposed to legs, hips and arms) is considered to be a greater risk factor for diseases of the cardiovascular system. Health risk increases in line with increasing waist:hip ratio. The measure of the waist is simply divided by the measure around the widest point of the hips. The following table provides some basic guidance on determining these potential risks.

Classification	Male	Female
High risk	> 1.0	> 0.85
Moderate risk	0.90 – 1.0	0.80 – 0.85
Low risk	< 0.90	< 0.80

Adapted from Van Itallie, (1988)

In preference to the 'waist:hip ratio' experts tend to favour the simpler and more reliable method of waist circumference measurement only. Risks of morbidity greatly increase with the following levels (these denote the recognised action levels whereby intervention becomes necessary).

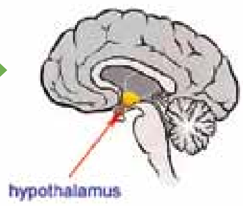
Lowered risk	High risk
Men < 94 cm (< 37 inches)	Men > 102 cm (> 40 inches)
Women < 80cm (< 32 inches)	Women > 88cm (> 35 inches)

N.I.H. (1998) Clinical guidelines on the identification, evaluation, and treatment of overweight and obese adults

The starvation response

Adipose tissue has been found to produce several signalling proteins or hormones, which appear to have far reaching effects on metabolism. One such hormone is leptin.

As fat cells increase in size they produce more leptin, and the levels of leptin are directly proportional to the levels of body fat or adipose tissue (Woods et al, 1998). Fat loss will reduce leptin levels, whilst fat gain will cause a corresponding increase (Kolaczynski et al, 1996; Weigle et al, 1997). If a reduction in body fat happens too quickly some studies have postulated that it may initiate the starvation response. This process is outlined below.



1. Decreased metabolism
2. Increased hunger
3. Increased LPL activity

Rapid fat loss causes severe reduction in leptin

Drop in leptin detected by hypothalamus Starvation response initiated

Response remains until leptin and body fat return to previous levels

*Lipoprotein lipase (LPL) is the enzyme responsible for moving triglycerides into adipocytes.

This starvation response is thought to have originated from our hunter gatherer evolutionary ancestors. As the body often went for long periods without food when meat was scarce, it developed a way of preserving its most valuable energy store, body fat, in order to assure longer survival. It also reduced daily calorie needs by reducing the volume of 'energy hungry' muscle tissue, thereby lowering metabolism.

Typical dieting alone will likely bring about this response and often leads to weight cycling up and down, which has been linked with poor nutritional levels of health. Understanding this response can help so that we do not restrict calories too severely and bring about a fat storing environment. To reset the body's "fat thermostat" requires a slower more sustainable rate of weight loss, accompanied by a gradual increase in physical activity.

Set point vs. settling point

Proponents of the 'set point' theory claim that we possess a genetically determined level of body fat and that any attempt to alter this level will cause metabolic adjustments designed to regain the previous "set point". This theory was postulated as an answer to the typical 'yoyo' dieting pattern that is commonly observed in those seeking to lose weight. Set point theory implies that any change to body composition that is not in line with genetics will in time be reversed.

Another theory that has been more recently proposed suggests that the human body is influenced by many environmental factors. The body will respond to these factors and find a point at which to 'settle' into a state of equilibrium. These influencing factors may include genetics, weather, eating habits, exercise and daily lifestyle. Settling point theory implies that we can affect an individuals' long term body composition by altering the environmental factors associated with weight gain.

Genetics

Genetic factors form part of the increasing epidemic of obesity, but they can not be seen to be the sole cause since the advance of the condition has occurred too quickly to be traced back to the gene pool alone. An individual's genetic make up may provide some contributory influence towards obesity, but the environmental factors of over-feeding, reduced activity, hormonal disruption and neural control will determine whether or not those genes are allowed to express themselves. In an environment conducive to producing obesity, people genetically prone to obesity will gain weight (Bouchard, 1997).

Energy and metabolism

The main components of overall energy expenditure are as follows:

Basal Metabolic Rate (BMR)
This is the sum total of all the reactions that occur in the body when at complete rest and no digestion is occurring. This is usually expressed as the number of calories needed to sustain those reactions.

Thermal Effect of Food (TEF)
The thermal effect of food refers to the amount of energy expended by the body through the ingestion, digestion, absorption, utilisation and storage of food. The TEF accounts for between 6-10% of daily energy expenditure for men and between 6-7% for women (Poehlman, 1989).

Thermal Effect of Activity (TEA)
The thermal effect of activity includes planned and unplanned levels of physical activity and the amount of energy required in support. Since research clearly indicates that low levels of activity are heavily implicated in the development of obesity, it follows that increasing levels of activity must play a major role in reversing this process. TEA is the most variable component of energy expenditure, and accounts for approximately 20% - 40% of total energy expenditure.

The following table will serve as a resource for common activities and the approximate number of calories per hour burned during participation for the average UK female (65kg) and the average UK male (79kg).

Activity	Male Kcal/hr	Female Kcal/hr	Activity	Male Kcal/hr	Female Kcal/hr
High impact aerobics	553	455	Dancing	356	293
Badminton	356	293	Rugby	790	650
Basketball	632	520	Golf – driving range	237	195
Light outdoor cycling	474	390	Horse riding	316	260
Building construction	435	358	Jogging	553	455
Heavy cleaning	237	195	Pilates	277	228
Table tennis	316	260	Pushing baby buggy	198	163
Swimming vigorous pace	790	650	Tennis	553	455
Volleyball	316	260	Brisk walking	395	325
Vigorous weight lifting	474	390	Sitting - busy at office	198	163

Total Daily Energy Expenditure (TDEE)

TDEE is the amount of calories we need on a daily basis to fuel all the functions, exercise and activity of the body. Knowing how to estimate the amount of calories we need per day can give us a starting point if calorie restriction is being used as part of weight management. Many people will begin a new exercise regime at the same time as starting a calorie controlled diet. This new exercise routine and increased energy expenditure will need to be supported if the adaptations and growth in fitness are to happen. Therefore, if any restriction in calories is considered important it needs to be applied with caution. In order to reduce the possibility of starvation response any calorie deficit should be pitched no higher than 250 calories less than the TDEE.

To determine an individual's personal TDEE based on their gender, height, weight, age and activity levels please turn to Appendix Part 2 'The Harris-Benedict Formula'.

Creating an energy deficit

A common approach to reducing body fat is to establish a negative energy balance. Research indicates that if the energy deficit is too great then body fat is more likely to return, possibly to an even greater level.

A priority for an effective weight management programme is to lose body fat, whilst retaining as much FFM or lean mass as possible thereby minimising the fall in metabolic rate (US Dept of Agriculture, 1995). The American College of Sports Medicine (ACSM) have suggested that to achieve this, a weight loss of - 1lb per week (ideally from body fat) is recommended.

Creating an energy deficit
Create a 500 kcal deficit per day
500 kcal deficit seven days a week
= 3500 kcal = 0.9lb (0.41kg)

This reduction in body weight may be achieved through several different strategies:

- diet restriction alone: reduce dietary intake by 500 kcal per day
- exercise intervention alone: increase exercise/activity by 500 kcal per day
- exercise and dietary restriction combined: increase exercise/activity by 250 kcal and reduce dietary intake by 250 kcal
- some other combination of dietary restriction and exercise related energy expenditure accounting for 500kcal deficit

The items above are only intended to highlight ways of achieving an energy deficit, not as the only solutions available. However, the figures are approximate and the rate of fat loss will vary from week-to-week and between different individuals:

- out of the above-mentioned interventions, the combination of exercise coupled with a modest dietary restriction has been proven from numerous studies to be the most effective method for achieving the desired negative energy balance, when compared with exercise and diet alone (Miller, 1991; Rachette et al, 1995; Wilmore, 1996).
- exercise and dietary restraint combined, has been shown to stimulate fat loss whilst minimising the loss of FFM and subsequent fall in metabolic rate (Ross, Pedwell, Rissanen, 1995).

Effective dietary interventions

If exercise interventions are most effective when correctly designed, implemented and evaluated, then the same must be true for any dietary interventions. The weight loss diet should contribute towards the desired energy deficit, whilst also providing sufficient nutrients required for health and normal functioning. Factors to consider include:

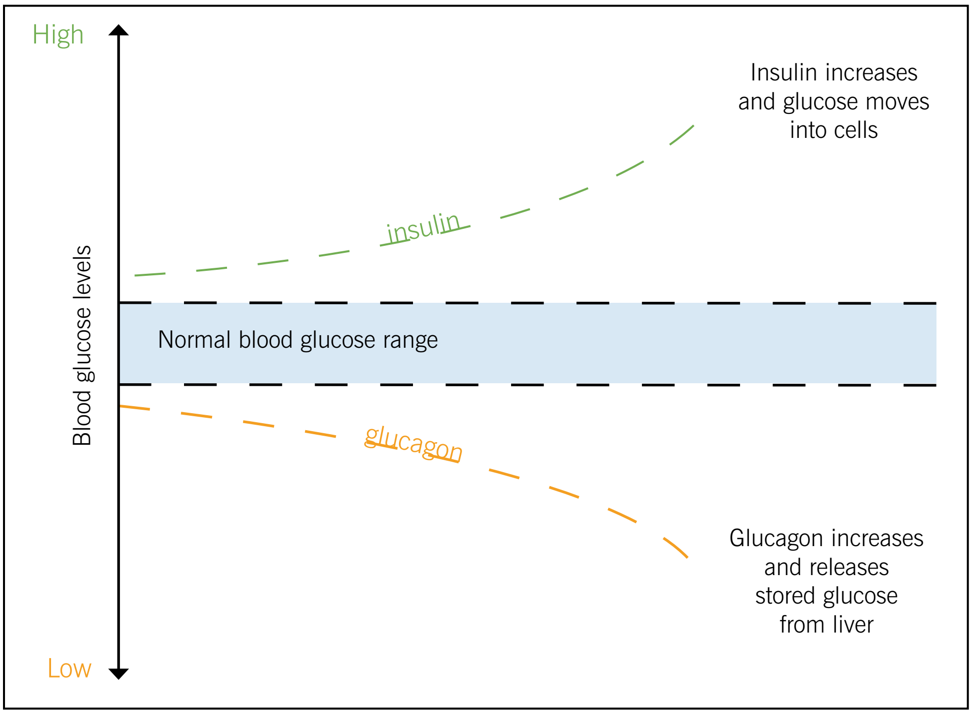
- frequency of meals
- effects of insulin
- biochemical individuality
- macronutrient balance

Frequency of meals

Advice to eat little and often is freely given so is there any rationale behind such advice? The answer is yes. Although the TEF over 24 hours is the same for several smaller meals totalling 1500 kcal as for one single meal totalling 1500 kcal, the physiological effects on the metabolism do differ. One study consisted of feeding two trial groups a total of 800 kcal per day. The first group had one meal per day, whilst the second consumed their 800 kcal from several smaller feeds. The group which consumed one meal a day experienced more hunger and a greater loss of FFM (Garrow, 1981). Both of these effects are detrimental to long term weight management. These results show that in order to minimise the loss of FFM and to avoid the subsequent fall in metabolism, regular meals throughout the day seems the most appropriate approach. A minimum of 3 meals a day is advised. Remember this can be a significant lifestyle change for many people and may require some thought and attention to address.

Blood glucose and insulin

Insulin plays a significant role in the storage of energy, and is a major contributing factor towards obesity. The following graph helps to illustrate the hormonal response in relation to high or low blood glucose levels:



Insulin drives glucose in the blood into the cells of the body for use. It primarily sends glucose to the muscles and liver where it is stored as glycogen. Glucose will be driven to other cells throughout the body. It will also send glucose into the adipose tissues. Higher insulin levels will encourage a faster rate of glucose converted and stored in adipose tissue. High glycaemic index foods and refined carbohydrates tend to cause insulin levels to 'spike' in an attempt to control rocketing blood glucose levels. This will favour fat storage and suppress the burning of fat as a fuel. Spiking often results in a subsequent crash in blood glucose, which creates tiredness and hunger and may in turn lead to overeating.

A high, refined carbohydrate diet has been implicated in reducing the efficacy of insulin and causing a level of resistance. Insulin resistance is closely linked to carrying too much body fat regardless of the macronutrient mix that exceeded the individual's energy needs. This is also a contributory mechanism in the chronic condition of diabetes. It is important to realise that insulin resistance is not just associated with increased body fat, but also with low levels of activity. Regular, moderate intensity aerobic exercise, incorporating large muscle groups has been shown to reduce insulin resistance by increasing insulin sensitivity particularly within the muscle tissue (Eriksson, 1999).

The actions of insulin include
• uptake of glucose into cells • promotion of glycogen synthesis • uptake of amino acids into cells • promotion of protein synthesis • suppression of fat breakdown and release from the adipose tissue • increased uptake of glucose into adipose tissue

Biochemical individuality

Whilst we share many similarities, we are each an individual biological entity in our own right, shaped by our genetic makeup and our environment. Our function is related to our structure. This is reflected from the whole body right down to the individual organs. For example, the size and shape of individual stomachs differ widely and in return exert an influence on our ability to digest and handle protein.

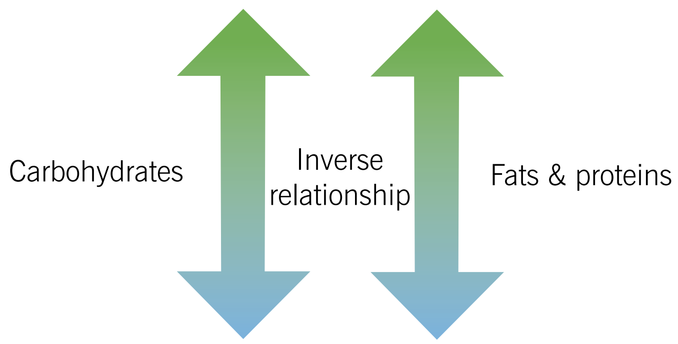
In dietary terms, what suits one person may not suit another. Before the advent of supermarkets and global food transportation, the foods available to different population groups were limited to what was grown or reared locally. This meant that people around the world ate very different diets with different macronutrient ratios and were still able to be healthy. Unfortunately, today most nutritional advice provided on mass as countrywide guidelines are a 'one size fits all' approach like the food pyramid or food plate. We all exhibit different physical, hormonal, chemical and cellular characteristics that will require different nutrient support. In the words of the Roman philosopher, "One man's food is another man's poison" (Lucretious, 200 BC). Trying to determine what foods will work for any given individual may require time, skill and a little trial and error.

Macronutrient balance

Macronutrient balance means that the intake of each macronutrient is equal to its needs within the body. Simply put, this means that we have to be able to metabolise and utilise the protein, carbohydrates and fats that we ingest. Any macronutrient, which is ingested in excess of our ability to utilise it, will be either stored or excreted. Clearly, there is some relevance to being out of balance with our macronutrient intake as this may increase the likelihood of storing body fat. Excess protein can contribute to increased body fat. Excess carbohydrates can contribute to increased body fat. Excess fat can also contribute to increased body fat. Perhaps too much emphasis has been placed on fats as being the major cause of increased body fat in recent years. All three macronutrients under the right conditions can be stored as body fat.

The increased intake or decreased intake of any one macronutrient will cause a change in the way the other two macronutrients may be metabolised by the body to meet energy or nutritional requirements. In nature, most foods that contain a significant source of protein also house a significant portion of fats. This is due to the necessary role that fats and fat soluble nutrients play in metabolising proteins. In nature also, it is often found that high carbohydrate foods have smaller proportions of fats and proteins.

When trying to realistically plan meals with varying macronutrient ratios an increase in protein will always also increase fats or vice versa. Therefore, in trying to meet a suitable macronutrient balance a possible guideline to consider is an inverse relationship between carbohydrates and fats/proteins.



Modern systems for weight management - whole food carbohydrate diet

The research: high carbohydrate, lower fat diets still constitute the mainstream approach:

- diets consisting of unrefined low glycaemic index carbohydrates alongside sufficient levels of monounsaturated fat have been shown to produce prolonged satiety (the state of being satisfactorily full). Therefore, they provide an effective method for reducing calorie intake and achieving long-term weight control (Ball et al, 2003)
- maintaining a carbohydrate based diet, but substituting saturated fat for greater amounts of monounsaturated fat, has been implicated with a reduced risk of CHD in overweight insulin resistant individuals (Connor and Connor, 1997)

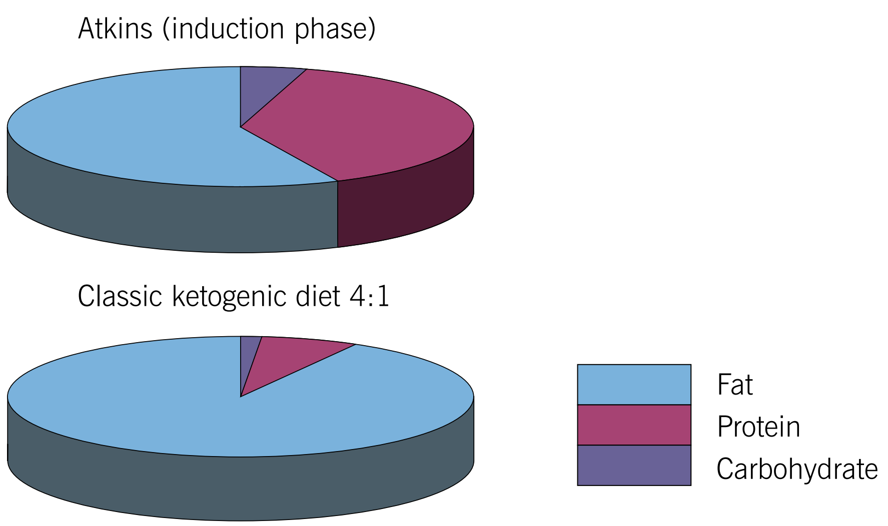
The dietary guidelines:

- cut out processed foods to reduce trans fatty acids
- reduce refined high glycaemic index carbohydrates
- reduce saturated fat and emphasise monounsaturated fat intake
- include oily fish or flax oil for omega 3 fatty acids
- maintain a ratio of 2:1 or 1:1 of omega 6 to omega 3 fatty acids
- include plenty of fresh fruit and vegetables
- include plenty of unrefined low to moderate glycaemic carbohydrates

Ketogenic diets

The principle

This is a high fat, moderate protein, low carbohydrate diet. The reduction in carbohydrate reduces blood glucose causing the body to undergo metabolic changes. The body responds by relying more on ingested fats for energy. Research has also shown a rise in the use of fatty acids from reserves within the adipose tissue. These fatty acids circulate to the liver where they are converted into smaller fragments and released back into circulation. These fragments are called keto acids or ketone bodies, and are easily utilised by various tissues as fuel. The individual is said to be in a ketogenic state under these environmental condition.



The research:

- higher protein/fat diets with reduced carbohydrate intake appear to improve blood lipid profiles in some individuals (Wolfe, 1995)
- replacing carbohydrate with protein/fat from meat, poultry, and dairy foods, produced beneficial metabolic effects and no detectable effects on markers of bone turnover or calcium secretion (Farnsworth et al, 2003)
- researchers found that low carbohydrate diets appeared to be effective for short-term weight loss in overweight adolescents, and did not harm the lipid profiles (Sondike et al, 2003). Caution with such diets was still advised

The dietary guidelines:

- the classic ketogenic diet contains a 4:1 ratio of fat by weight to combined protein and carbohydrates
- protein intake is usually targeted at 1g per kg body weight per day
- the Atkins diet typically had a higher protein intake than the classic ketogenic approach
- reduction in starchy carbohydrates including some fruits and vegetables, bread, rice, pasta, grains and sugar
- the initiation phase may limit carbohydrates to as low as 20g per day which increases once moving into the ongoing maintenance phase by 5g of carbohydrates more per day across each week until an optimal level is found
- increase sources of fats like butter, cream, olive oil and particularly coconut oil

Considerations

Whilst some individuals may thrive on these ketogenic diets, they are by no means suitable for everyone, and are associated with some inherent risk factors. Concerns include increased fat intake and CHD risk, protein turnover and kidney function and blood acidity and calcium reduction in bones.

These diets are considered extreme and restrictive by some experts, but may well suit a proportion of individuals, providing improvements in fat loss, insulin resistance and blood lipid profiles. However, they may equally be less suited to others, especially people with a history of kidney function problems. The ability to thrive on these diets may be down to biochemical individuality and genetics.

The Palaeolithic Diet

The concept

The basic argument centres on the fact that 99.9% of our genes were formed 10,000 years ago by the beginning of the Neolithic or agricultural era. By logical argument proponents of this argument suggest that we are better suited to the Palaeolithic (over 10,000 years ago) diet, since this is what we evolved with.

The dietary guidelines:

- approximately 30% protein intake, varied according to season. Protein should come from wild game meat such as venison, bison, rabbit and fowl (Eaton and Konner, 1983)
- an ideal ratio of 1:1 up to possibly 1:4 omega 6 to omega 3 fatty acids
- a greater percentage of monounsaturated fat, and less saturated fat
- carbohydrates are limited to seasonal fruit, wild vegetables, roots, legumes and nuts
- the hunter gatherer life style was very physically active, an important component relating to this diet

The basis of the diet is a return to the foods that would have been available to us in a Stone Age setting, whilst avoiding the modern mass agricultural foods available today that would not likely have been present.

Avoid the following Neolithic foods
• all grains e.g. wheat, rye, barley, oats etc. • all grain products e.g. bread and pasta • all processed food • milk and dairy products • all pulses e.g. beans of any kind, including string beans, peas, • cashews • potatoes and sweet potatoes • sugar

Include the following Palaeolithic foods
• a variety of organic meat, poultry • organic organ meats e.g. liver and kidneys • organic free range eggs • plenty of fruits (strawberries, raspberries, blueberries etc) • plenty of root vegetables (carrots, turnips, parsnips, swedes, radishes etc) • plenty of broad green leafed vegetables (lettuce and spinach leaves, kale etc) • bulbs (onions, garlic) • nuts and seeds

Considerations

This diet may not be the solution for everyone; yet again others may thrive on it. Critics argue that it is restrictive and some may find it hard to adhere to. Others express concern that the lack of dairy produce may result in poor calcium intake, although dark green leafy vegetables are a plant source of calcium and magnesium.

The Palaeolithic diet does have some favourable points. The exclusion of processed food has to be an improvement for everyone, reducing sugar, heavily refined carbohydrates and trans fats within the diet. Most sides in nutrition recognise the importance of increased fruit and vegetables and an improved ratio of omega 3 to omega 6 essential fats.

Concerns still exist within some quarters over the increased intake of saturated fat. Although a significant percentage of fat within most red meat is in fact monounsaturated, which experts have identified as being beneficial to health. The amount of saturated fat within domesticated livestock tends to be higher than within the original Palaeolithic wild game.

Anorexia and bulimia nervosa

Excess body weight is the most common side of the weight management equation, but a small but significant area is the management of weight in those who are seriously underweight. The most common and widely recognised eating disorders that lead to underweight are anorexia and bulimia nervosa. Both conditions can be very difficult and often provide awkward circumstances to face up to. It should be recognised that while the common outward symptoms are not eating enough food or vomiting food after meals, the root cause of the problems are usually psychological in nature.

Sufferers are often in denial about their problem or are desperately trying to hide their behaviour, so nutritional advice alone does not normally have much influence. Appropriate professional help should be sought if or when dealing with individuals suspected of suffering from one of these challenging conditions.

The National Institute for Clinical Excellence (NICE) released guidance in 2004 to assist practitioners in managing eating disorders. They advocate that most people with anorexia nervosa can be managed on an outpatient basis with appropriate psychological treatment and additional family interventions where children or teenagers are concerned. NICE encourage people with bulimia nervosa to be guided using established, evidence-based self help programmes and where needed may be prescribed anti-depressants. Bulimics are also advised to undergo cognitive behaviour therapy specifically adapted for bulimia nervosa and normally lasting a period of 4-5 months. Family members should be included in the treatment of eating disorders by assisting with needed behavioural change and facilitating good communication.

The tables below list the signs and symptoms associated with anorexia nervosa and bulimia nervosa to assist in the recognition of these debilitating psychological conditions:

Signs and symptoms of anorexia nervosa			
Physical	Psychological	Behaviour	Long term
• extreme weight loss • insufficient growth • constipation or abdominal pains • dizzy spells • hair loss • poor circulation • dry, rough discoloured skin • dysmenorrhoea • loss of bone density	• intense fear of gaining weight • distorted perception of body • denial of problem • mood swings	• rituals attached to eating • secrecy • restlessness and hyperactivity • wearing baggy clothes • vomiting and / or taking laxatives	• difficulty in becoming pregnant • osteoporosis • death

Signs and symptoms of bulimia nervosa			
Physical	Psychological	Behaviour	Long term
• frequent weight changes • going to the toilet after meals • sore throat and tooth decay • swollen salivary glands • swollen face • poor skin • dysmenorrhoea • lethargy and tiredness	• uncontrollable urges to eat • an obsession with food • distorted perception of body • mood swings • anxiety and depression • low self esteem, shame and guilt	• bingeing and vomiting • excessive use of laxatives • periods of fasting • excessive exercise • secrecy	• heart attack • rupture in stomach • erosion of teeth • choking

Eating Disorders Association www.edauk.com
Telephone helpline: 0845 634 1414

Consult, communicate and goal set

Introduction

In order to work with a client in understanding and empowering them to make changes to their eating habits it is imperative that a trusting and supportive professional relationship is established. This will assist in opening the channels of honesty and communication that are essential in facilitating dietary change. Unlike personal training, which is performed face-to-face, mealtimes, snacks and eating in general happens outside of the trainer's eyesight. The client, therefore, must have a certain degree of motivation, discipline and integrity and a professional who can tap into their wavelength to be able to guarantee that long term changes are maintained.

Prior to collecting a client's personal information on health and diet it is vital that the health professional has obtained a written and signed 'informed consent' form. This will protect both the trainer and client and ensure that sensitive information remains confidential and that the client doesn't receive any unexpected surprises with the type or level of service as they have been 'informed' prior to the nutrition service beginning. There are many ways in which to gather information from a client in an effort to guide and offer advice on nutrition. These methods may include:

- questionnaires e.g. lifestyle, PAR-Q, medical, nutritional
- completed food diary
- interviewing / consulting
- short and long term observation e.g. body language, long term behaviours, habits, reactions, emotions, health
- nutritional testing / assessing

It is very important that a sufficient amount of accurate information is gathered by any nutrition or health and fitness professional prior to offering advice and direction. This will help in more fully understanding the clients' current situation in relation to where they really need to be. This will also serve as the foundation to determine the correct, individualised stages of change to ease and guide a client through a series of adjustments to their current lifestyle and food habits. When gathering information through interviewing the consultant should:

- communicate clearly and effectively to be sure knowledge shared is understood by both the trainer and the client
- generate enthusiasm and motivation for change
- be aware of the effect of their personal attitudes and beliefs and avoid being too judgemental
- understand the constraints on an individuals' health and nutrition behaviour, including family, employment, cultural and religious considerations
- foresee any obstacles that may reduce adherence to nutritional change and investigate tactfully using appropriate questioning
- determine a variety of options suitable to the clients' lifestyle that will move them towards their goals

Communication

Good communication during a single consultation process and across the weeks and months that change is being implemented is important for success. The reasons for this are:

- communication is essential to the professional relationship. It must be appreciated that people communicate in different ways and that the trainer must determine what style or method of communication best suits the client and then adapt their style to match
- communication is a primary skill needed to convey knowledge to other people. There are very well educated, knowledgeable people who do not achieve their potential because they cannot communicate their knowledge in a way that other people can effectively understand them. This means that great knowledge remains trapped within them rather than benefitting others
- communication is a vital key to retaining or losing clients. Once a trainer starts to communicate effectively they can build rapport, relate, empathise, explain, understand, motivate, question and laugh with a client. All important aspects of building relationships of trust
- good communicators build good relationships. This is because they can convey what they want or need in a form the other person understands. However, they are also able to understand what the other person is feeling and needs. To communicate well the trainer needs to put themselves in the other person's place and see the world from their point of view

"If you can tell someone what you want it vastly improves your chances of actually getting it." (Simon Rea)

Conditions which promote effective consultation / interview

The room:

- comfortable, bright, airy, warm or cool (as appropriate)
- no barriers e.g. a desk between people
- comfortable chairs, not opposite each other but angled to allow for eye contact, but also to enable client to break eye contact easily whilst they think about their responses
- no loud noises or distractions, professional privacy to be maintained
- no prominent clocks

The consultant:

- genuine, a person of integrity, open-minded
- having unconditional regard for the client
- posture and body language should be welcoming

It is necessary to establish a climate in which a client can 'open up'. Warmth, openness, genuineness, empathy and unconditional positive regard can achieve this. Through giving their full attention, actively listening, encouraging the client to talk and by asking questions, the consultant begins to establish trust and to encourage the client to explore relevant issues.

Using questionnaires

The clients' PAR-Q, lifestyle, medical and nutrition questionnaire can provide valuable information when trying to encourage change and reform. It can serve as a basis for which to follow a stream of viable questioning and it will help to identify potential barriers and solutions such as:

- time available to purchase food, and prepare meals
- family commitments that may hinder efforts
- employment commitments and degree of priority
- potential support network
- social habits and activities that support or hinder
- health problems that may require more specialist care

Nutrition questionnaires can provide a valuable broad screen of information from which to base a consultation around. However, it should be noted that questionnaires are often answered by the client in a way that emphasises what they perceive to be the positive elements of their dietary habits and minimises the areas they perceive to be 'bad'. This leads to inaccuracies in judgement and in the information that the health professional is working with. With this in mind, it is always advisable that some form of food diary is utilised to obtain a more accurate base of information to work from.

Effectively using a food diary

Ensuring the correct use of a food diary is paramount to collecting accurate information about the clients eating habits. Time should be taken to ensure the client fully understands what information should be recorded and when it should be done. The importance of trust and rapport with a client prior to asking them to complete a food diary is paramount. A poorly established professional relationship is much more likely to lead to dishonesty and an intentionally adjusted food diary that will not provide the true dietary habits of the individual. Consider these points when using a diary:

- complete diary after each meal, not at the end of the day
- record accurately what was eaten
- identify amounts eaten
- identify food brands and quality of food where possible
- note the time of intake
- specify any fluid intake e.g. water, coffee, soft drinks
- note when activity or exercise was done
- assess energy, mood, and mental clarity 1-2 hours after food was eaten

After information has been gathered using a food diary the information needs to be correctly analysed and interpreted. This is a skill that takes some practise. The more often a professional reviews food diaries the easier it becomes to extract relevant and important information contained within the list of foods recorded. Whilst it is difficult to identify a comprehensive list of all possible information that can be drawn out of an effectively recorded food diary the following will provide a starting point:

- amount of carbohydrate in the daily diet
- level of refinement of carbohydrate foods
- energy, mood and mental response to high carbohydrate intake
- varied fruit and vegetable intake
- amount of protein in the daily diet
- inclusion of protein in each meal
- quality of the sources of protein
- energy, mood and mental response to high protein intake
- amount of fat in the daily diet
- types of fat included
- quality of the sources of fat in the diet
- sources of omega 6 to omega 3 and the current ratio
- timing of meals generally throughout the day
- how food fits in around the working day and family commitments
- food intake around activity, exercise and other key stressors

- regularly eaten foods that may form part of subconscious, addictive patterns
- fluid intake and how this measures up to guidelines and additional exercise needs
- alcohol habits and intake
- additives that are ingested regularly and the potential side effects
- 'go to' foods that serve to satisfy when quick and convenient options are a must
- look for repetitive eating patterns with little variety

Providing feedback

Following an in depth analysis of a client's food diary it is essential to provide accurate and valid feedback. It is important to be able to provide both positive feedback and highlight areas of attention that need to be improved upon. The health professional should not determine the goals beforehand and arrive at the feedback session with a set of goals to impose upon the client. This will more likely lead to poor adherence and rebellion from the client because the health professional has not determined what works best for their life and circumstances but merely from an intellectual stand point identified specific changes that must be made.

Some clients may have many areas that need to be worked upon that could prove to be too vast for a client to get to grips with in one go. Therefore, the areas of needed change should be prioritised by considering which are most nutritionally important, but also which would be the easiest changes to make.

The language and manner in which negative feedback is discussed after analysing a food diary should also be carefully considered. Whilst we do not want to upset or offend a client, it is still our duty and role to honestly inform the client of detrimental nutritional habits and to make necessary changes clear. The areas of concern should first be highlighted in a factual, but non-judgemental manner then through appropriate questioning the client's willingness to change in this specific area should be ascertained. This may be done across each topic area where the trainer feels the need for some adjustment in dietary habits. This will help the trainer understand better which areas the client has shown greater willingness and greater resistance to change by listening to their verbal responses, the tone and pitch of their voice, their facial expressions and body language whilst discussing each potential area of change.

Identify options and set appropriate goals

Having gained a new perspective on the issues and concerns, it becomes possible for the client to identify goals and ways in which these might be achieved. The important thing about this stage is that the client is allowed time to talk through the potential areas of change by considering the likely consequences of change, both positive and negative. The trainer should listen to and record their thoughts and views. These should then be reviewed and options to achieve each target discussed and implemented alongside measures that could be taken to overcome any possible barriers.

By discussing the options, the trainer will discover much more about the client's attitude and beliefs and the way in which they think about the different dietary habits and behaviours they have. This will also aid the client in developing ownership of agreed goals and the strategy that is decided upon.

A client may have a number of different objectives in mind when it comes to nutrition:

- body fat reduction or weight loss
- muscular development
- eating to achieve optimal health
- fuelling exercise and/or sport

Whatever their intentions may be, it is essential to work with the client to set appropriate goals that fall in line with the SMART principle:

S - specific statement of the objective
M - measurable in order to provide comparative progress
A - agreed by the client involved
R - realistic whilst still providing a challenge
T - time framed to focus effort and attention

The time frame of goals should vary in relation to the priorities that were originally discussed to help set long, medium and short term goals. This can aid the client in breaking things down into more manageable, bite-size chunks. Having made a decision, the client now needs to turn that decision into action. The trainer and client should also look to include coping strategies and sources of support where needed.

Once an action plan has been agreed, it must be recognised that there will be a need to regularly monitor progress through follow up consultations, food diaries and assessments. As time progresses and the client begins to achieve the initial priorities it is important to drip feed the other lesser priority objectives into the strategic formula. Goals should be written and placed somewhere the client will see them on a regular basis but not to be overpowering, such as where all their work colleagues can see what they are doing.

The performance equation (G. Tim Gallwey)

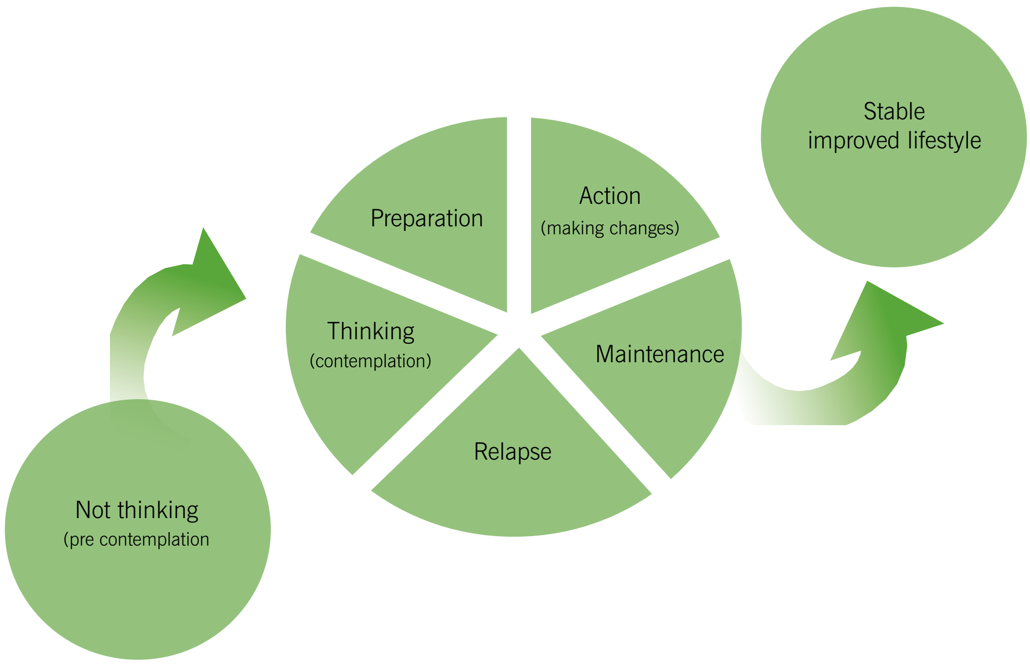
This performance model helps to explain why some people are effectively able to focus and achieve and why others may struggle to fulfil the outcomes of which they are capable.

Performance		**Potential**		**Psychological Interference**
Results or outcome	=	Education, experience, knowledge, skills, determination and commitment	–	Low motivation, low confidence, lack focus, stress, anxiety, limiting beliefs and behaviours

Those clients who are able to remain focused on their potential, act in accordance with their objectives and take 100% responsibility for their outcome are rarely distracted by interference. Some, however, sabotage their potential through their own psychological interference, particularly through lack of motivation and the perpetuation of their own limiting beliefs and opinions about themselves or the methods being used to make change occur. Therefore, we need to work on each client's psychological interference factors to maximise their potential, generate greater focus and maintain consistent motivation.

Investigate concerns and identify barriers

Having a good understanding of the behavioural change model is a tool that will aid the trainer to assess where a client is in relation to their efforts to alter their lifestyle. Given this understanding, suitable behavioural change strategies can then be implemented. The behavioural change model states that individuals go through several distinct stages in adopting a new behaviour:



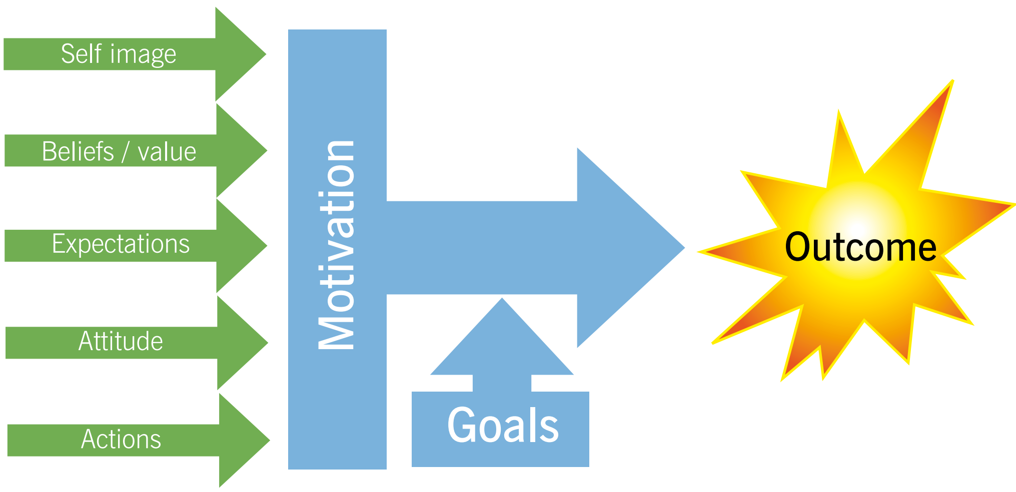
Sometimes people want to change but are afraid of the consequences or concerned how they will cope. It may help the client just to have an opportunity to air these concerns to a sympathetic listener. Often the health professional will be able to contribute information that will allay fears or be able to offer suggestions about how these concerns could be taken into account in the action plan. It is important not to be dismissive regarding a client's concerns even if they may seem trivial or irrelevant.

When a person prepares to make changes, he or she needs to take account of things he or she liked about the old lifestyle. They need to accept that the reasons for the old behaviour will still be around and will sometimes seem to be more important than the reasons for changing. It will be important to develop strategies for handling such 'temptation'.

Examples of the kind of barriers that may be faced are:

- client enjoyed the taste of less healthy food
- comfort eating to improve feelings and emotions during stressful times
- financial concerns over cost of better quality food
- family members, spouse or partner may not want to change
- time constraints may support low quality, convenience eating
- they have become accustomed to certain habits and routines that are difficult to break

Performance model



There are many complex contributing factors that will determine an individual's level of motivation and adherence to their planned outcome. The performance model above identifies many of these integrating factors. The greatest levels of success will only be obtained when all of these factors are working in positive alignment. Then motivation to apply the goals that are set will be such a great driver for action that it will not be a question of if they achieve, but rather when they achieve.

There are many ways and tools which a nutritional advisor or personal trainer can use to support the client whilst they strive to keep their focus on the objectives at hand.

Motivational strategies

Self monitoring:

- recording of thoughts, feelings and situations before, during and after the target behaviour. Strategies can then be developed to cope with barriers and make good use of available support networks

Reinforcement:

- rewarded for positive results and small achievements
- monitoring of positive progress – comparison to previous performance
- social support from family, friends and colleagues

Behavioural contracts:

- should include clear, realistic objectives and deadlines
- tailored to the individual
- followed up and re-evaluated regularly during the maintenance stage

Provide praise:

- seek and identify specific examples of good behaviours and take the time and effort to praise and thank client for their efforts

Encourage paired or group participation:

- this can provide social accountability to ensure adherence
- for social camaraderie and commitment

Recruit supportive 'other':

- it is important that whoever the 'other' person is, that they are supportive in a positive and not a negative way

Periodic testing for positive reinforcement:

- to give information about progress towards goals and opportunity to provide positive reinforcement and curb regressive behaviours
- should map in with goals across various time frames set
- could include body fat, BMI, circumferential measures and food diary analysis

Use behavioural change strategies:

- examples might include participants self-goal setting, past experience influence, self motivation positive statements, self-efficacy, short term achievable goals
- decision balance sheets
- segment intending
- performance profiling to identify patterns and methods of individual motivation

Charting progress:

- both trainer and client to note and record progress (including psychological) on a regular basis to give positive feedback
- using energy, mood and mental clarity scores on food diaries can provide a way of seeing trend changes

Reward systems:

- for example, show consistency in a certain food habits for a month and receive a free gift or service such as a T-shirt, water bottle, massage or PT session

Liaising with others

There may be times when the trainer needs to discuss or work with other professionals or family members to help the client achieve their best results. This is in the trainer's interest and is considered sound and ethical practice. The trainer needs to be sure that they do not encroach on another professionals work and that they are trying to bring about the best result for the client. A channel of open communication between the trainer and other professionals will help them to combine their efforts for the good of the client. Family members, spouses, partners and friends can be absolutely vital in the success of the client. They indeed can be pulled in to serve as a support network, rather than a hindrance to assist the client to maintain their behavioural and motivational changes.

A variety of professionals and people that may play a role in the success that is achieved by the client are illustrated below.

Data protection

Consulting with a client will always provide valuable information to assist in producing solutions. However, it is vital that we are sensitive to the client and the confidential information a trainer may become privy to. Information that is divulged during a consultation can cover areas such as personal health, dietary failures, personal beliefs, family stresses, abusive relationships, depressive eating habits, self loathing, and many other sensitive topics. Whilst these topics will indeed help in understanding the client, their behaviours and potential barriers, this information must be treated with the basic privacy and respect that any decent human being deserves.

Consent should be obtained from the individual prior to recording their personal information. It must be remembered that when information is gathered in any context from an individual that we must conform to the regulations of the Data Protection Act 1998. As data controllers, nutritionists or trainers must satisfy two obligations:

First obligation, adhere to the following:

- information is fairly and lawfully processed
- the information is used for the limited purposes intended and known by the client
- there is adequate information for the required purpose
- the information held is all relevant and not beyond the purpose or needs
- all information is accurate and current
- information should only be stored or held on file for the required time period
- information is stored in fire-proof lockable filing cabinets, or under password protection on a computer
- information should not breach an individual’s rights
- information should not be passed on to others without the individuals permission, and should not be used outside the EC unless adequate protection for the individual is in place

Second obligation:

Inform the information commissioner. A form can be completed online at www.dpr.gov.uk

Appendix 1 - Food reaction diary

Week	Breakfast & snacks Awake – 12.30pm			Lunch & snacks 12.30 – 5.30pm			Dinner & snacks 5.30pm - Sleep		
Day									
Reaction rating	Appetite Cravings	Energy	Mind Emotions	Appetite Cravings	Energy	Mind Emotions	Appetite Cravings	Energy	Mind Emotions
1-2 hours after eating	Full	Renewed	Uplifted	Full	Renewed	Uplifted	Full	Renewed	Uplifted
	Satisfied	'Lasting' energy	Mental Clarity	Satisfied	'Lasting' energy	Mental Clarity	Satisfied	'Lasting' energy	Mental Clarity
Scale: 1 - 4 1 = low 4 = high	Sweet cravings	Hyper, but weary	Irritable apathy	Sweet cravings	Hyper, but weary	Irritable apathy	Sweet cravings	Hyper, but weary	Irritable apathy
	Need a snack	Sleepy tired	Lack of focus	Need a snack	Sleepy tired	Lack of focus	Need a snack	Sleepy tired	Lack of focus
Week	Breakfast & snacks Awake – 12.30pm			Lunch & snacks 12.30 – 5.30pm			Dinner & snacks 5.30pm - Sleep		
Day									
Reaction rating	Appetite Cravings	Energy	Mind Emotions	Appetite Cravings	Energy	Mind Emotions	Appetite Cravings	Energy	Mind Emotions
1-2 hours after eating	Full	Renewed	Uplifted	Full	Renewed	Uplifted	Full	Renewed	Uplifted
	Satisfied	'Lasting' energy	Mental Clarity	Satisfied	'Lasting' energy	Mental Clarity	Satisfied	'Lasting' energy	Mental Clarity
Scale: 1 - 4 1 = low 4 = high	Sweet cravings	Hyper, but weary	Irritable apathy	Sweet cravings	Hyper, but weary	Irritable apathy	Sweet cravings	Hyper, but weary	Irritable apathy
	Need a snack	Sleepy tired	Lack of focus	Need a snack	Sleepy tired	Lack of focus	Need a snack	Sleepy tired	Lack of focus

Positive reactions

Negative reactions

Week	Breakfast & snacks Awake – 12.30pm			Lunch & snacks 12.30 – 5.30pm			Dinner & snacks 5.30pm - Sleep		
Day									
Reaction rating	Appetite Cravings	Energy	Mind Emotions	Appetite Cravings	Energy	Mind Emotions	Appetite Cravings	Energy	Mind Emotions
1-2 hours after eating	Full	Renewed	Uplifted	Full	Renewed	Uplifted	Full	Renewed	Uplifted
	Satisfied	'Lasting' energy	Mental Clarity	Satisfied	'Lasting' energy	Mental Clarity	Satisfied	'Lasting' energy	Mental Clarity
Scale: 1 - 4 1 = low 4 = high	Sweet cravings	Hyper, but weary	Irritable apathy	Sweet cravings	Hyper, but weary	Irritable apathy	Sweet cravings	Hyper, but weary	Irritable apathy
	Need a snack	Sleepy tired	Lack of focus	Need a snack	Sleepy tired	Lack of focus	Need a snack	Sleepy tired	Lack of focus
Week	Breakfast & snacks Awake – 12.30pm			Lunch & snacks 12.30 – 5.30pm			Dinner & snacks 5.30pm - Sleep		
Day									
Reaction rating	Appetite Cravings	Energy	Mind Emotions	Appetite Cravings	Energy	Mind Emotions	Appetite Cravings	Energy	Mind Emotions
	Full	Renewed	Uplifted	Full	Renewed	Uplifted	Full	Renewed	Uplifted
1-2 hours after eating	Satisfied	'Lasting' energy	Mental Clarity	Satisfied	'Lasting' energy	Mental Clarity	Satisfied	'Lasting' energy	Mental Clarity
	Sweet cravings	Hyper, but weary	Irritable apathy	Sweet cravings	Hyper, but weary	Irritable apathy	Sweet cravings	Hyper, but weary	Irritable apathy
Scale: 1 - 4 1 = low 4 = high	Need a snack	Sleepy tired	Lack of focus	Need a snack	Sleepy tired	Lack of focus	Need a snack	Sleepy tired	Lack of focus

Appendix 2 - The Harris Benedict Formula

This is a calorie formula using the factors of height, weight, age, and sex to determine basal metabolic rate (BMR). This makes it more accurate than determining calorie needs based on total bodyweight alone. The only variable it does not take into consideration is the amount of lean body mass. Therefore, the equation will be very accurate in all but the extremely muscular (it will underestimate caloric needs) and the extremely over fat (it will over estimate caloric needs).

Men: BMR = 66 + (13.7 x weight in kg) + (5 x height in cm) – (6.8 x age)

Women: BMR = 655 + (9.6 x weight in kg) + (1.8 x height in cm) – (4.7 x age)

Note: 1 inch = 2.54 cm
1 kg = 2.2 lbs
1 stone = 14 lbs

Example:

You are female
You are 30 yrs old
You are 5' 6" tall (167.6 cm)
You weigh 8 stone 8 lbs (54.5 kg)

Your **BMR** = 655 + 523 + 302 – 141 = **1339 calories/day**

Now that you know your BMR, you can calculate Total Daily Energy Expenditure (TDEE) by multiplying your BMR by your activity multiplier from the chart below:

Activity Multiplier

Sedentary	BMR x 1.2	(little or no exercise, desk job)
Lightly active	BMR x 1.375	(light exercise/sports 1-3 days/week)
Mod. Active	BMR x 1.55	(moderate exercise/sports 3-5 days/week)
Very Active	BMR x 1.725	(hard exercise/sports 6-7 days/week)
Extra Active	BMR x 1.9	(hard daily exercise/sports and physical job)

Example:

As above BMR is 1339 calories/day
Your activity level is moderately active (work out 3 – 4 times a week)
Your activity factor is 1.55
Your TDEE = 1.55 x 1339 = 2075 calories/day

Appendix 3 - Nutritional analysis and goals summary

Performing an analysis of a client's food diary can be both fairly quick and simple or incredibly in depth and full of vast amounts of information. There are many different areas that can be investigated to seek out and provide useable information to serve as a platform for providing suitable advice to guide appropriate behavioural change and set goals. Regardless of how much analysis is carried out on a food diary this information needs to be condensed into a simple format that can be useful to both the trainer and the client alike. The following form is designed to provide a basis for charting the key dietary strengths and weaknesses and linking them directly to agreed goals and strategies for bringing about change.

The form charts meals, snacks, macronutrients, micronutrients and water intake and the goals that are associated with each nutritional analysis category. This will help focus the trainer on vital information that can make a significant difference to good health, physical performance and weight management without getting too bogged down in the finer details. This does not mean that smaller objectives, like balancing out essential fatty acids, are not important and this could still be one the necessary goals to focus on, but it ensures that the major categories are considered and managed effectively.

Nutrition analysis category	Quantity	Dominant quality/ type	Required change	Transitional steps	Timeframe	Date goal achieved
Meals	Breakfast: Lunch: Dinner:	Breakfast: Lunch: Dinner:	1. 2. 3.	1. 2. 3.	1. 2. 3.	1. 2. 3.
Snacks	Number times per day: 1 2 3 4 5	Excellent Good Satisfactory Average Poor	1. 2. 3.	1. 2. 3.	1. 2. 3.	1. 2. 3.
Protein	Total daily kcals: % daily kcals	Excellent Good Satisfactory Average Poor	1. 2. 3.	1. 2. 3.	1. 2. 3.	1. 2. 3.
Fats	Total daily kcals: % daily kcals:	Excellent Good Satisfactory Average Poor	1. 2. 3.	1. 2. 3.	1. 2. 3.	1. 2. 3.
Carbohydrates	Total daily kcals: % daily kcals:	Excellent Good Satisfactory Average Poor	1. 2. 3.	1. 2. 3.	1. 2. 3.	1. 2. 3.
Vitamins and minerals	Excellent Good Satisfactory Average Poor	Food source – poor Food source – good Food source – great Supplement – poor Supplement - good	1. 2. 3.	1. 2. 3.	1. 2. 3.	1. 2. 3.
Water	Litres per day:	Tap water Plastic – average Filtered tap water Plastic - good Glass - good	1. 2. 3.	1. 2. 3.	1. 2. 3.	1. 2. 3.

References

Acheson et al. (1988). Glycogen storage capacity and de novo lipogenesis during massive carbohydrate overfeeding in man. *The American Journal of Clinical Nutrition*, **48**, 240-7

Ball et al (2003). Prolongation of satiety after low versus moderately high glycemic index meals in obese adolescents. *Pediatrics*, **111**(3), 488-494

Bouchard, et al. (1997). Human variation in body mass: evidence for role of genes. *Nutrition Reviews,* 55, S21

Cardwell, G. (1999). *Antioxidants and sport*. www.ptonthenet.com

Conner, W.E. and Conner, S. L. (1997). Should a low fat, high carbohydrate diet be recommended for everyone? The case for a low fat, high carbohydrate diet. *New England Journal of Medicine,* **337**, 562-563

Eating Disorders Association (2007). www.edauk.com

Eaton, S.B. and Konner, M. (1983). Palaeolithic nutrition: a consideration of its nature and current implications. *New England Journal of Medicine,* **312**, 283-289

Eriksson, J.G. (1999). Exercise and the treatment of type II Diabetes Mellitus. An update. *Sports Medicine*, **27**(6), 318-391

Enig, M.G. (1991). Trans Fatty Acids in the Food Supply: *A Comprehensive Report Covering 60 Years of Research, 2nd Edition,* Enig Associates, Inc, Silver Spring, MD

Farnsworth et al. (2003). Effect of high protein, energy restricted diet on body composition, glycemic control, and lipid concentrations in overweight and obese hyperinsulemic men and women. *The American Journal of Clinical Nutrition,* **78**(1), 31-39

Food Standards Agency (2007). www.food.gov.uk

Garrow, J.S. and Webster, J.D. (1989). Effects of weight and metabolic rate of obese women of a 34 MJ (800 kcal) diet. *Lancet,* **1** (8652), 1429-1431

Helmrich, S.P., Ragland, D.R., Leung, R.W. and Paffenbarger, R.S. (1991). Physical activity and reduced occurance of non-insulin-dependant diabetes mellitus. *New England Journal of Medicine*, **325**, 147-152

Hornung, B., Amtmann, E. and Sauer, G. (1994). Lauric acid inhibits the maturation of vesicular stomatitis virus. *Journal of General Virology,* **75**,353-361

Kris-Etherton et al. (1999). High monounsaturated fatty acid diets lower both plasma cholesterol and triglycerol concentrations. *The American Journal of Clinical Nutrition,* **70**, 1009-1015

Llewelyn et al. (2001). *FAC Review of the use of the terms Fresh, Pure, Natural etc.* in Food Labelling. Food Standards Agency, www.food.gov.uk

Malina, R. and Bouchard, C. (1991). *Growth, maturation, and physical activity*. Champaign, IL:: Human Kinetics

McCullough et al. (2000). Adherence to the Dietary Guidelines for Americans and the Risk of Major Chronic Disease in Women. *The American Journal of Clinical Nutrition*, **72** (5), 1214-1222

McDevitt et al. (2001). De novo lipogenesis during controlled overfeeding with sucrose or glucose in lean and obese women. T*he American Journal of Clinical Nutrition*, **74**, 737–46

Mead et al. (1986). *Lipids: Chemistry, Biochemistry and Nutrition*. Plenum Press, New York

Mensink, R.P.M and Katan, M.B. (1990). Effect of dietary trans fatty acids on high-density and low-density lipoprotein cholesterol levels in healthy subjects. *New England Journal of Medicine,* **323**, 439-445

Miller, W.C. (1991). Diet composition, energy intake, and nutritional status in relation to obesity in men and women. *Medicine and Science in Sports and Exercise,* **23** (3), 280-284

Millstone and Lang (2004). *The Atlas of Food: Who Eats What, Where and Why,* Earthscan

Nanji et al. (1995). Dietary saturated fatty acids: a novel treatment for alcoholic liver disease. *Gastroenterology,* **109**, 547-554

Poehlman, E.T. (1989). A review: exercise and its influence on resting energy metabolism in man. *Medicine and Science in Sports and Exercise,* **21**, 515-525

Projan, et al. (1994). Glycerol monolaurate inhibits the production of beta-lactamase, toxic shock toxin-1 and other staphylococcas exoproteins by interfering with signal transduction. *Journal of Bacteriology,* **176,** 4202-4209

Rachette, et al. (1995). Effects of aerobic exercise and dietary carbohydrate on energy expenditure and body composition during weight reduction in obese women. *The American Journal of Clinical Nutrition,* **61**, 486

Robinson, J.I., Hoeer, S.L., Petersmarck, K.A. and Anderson,J.V. (1995). Redefining success in obesity intervention: the new paradigm. *Am. J. Diet. Assoc.*, **4**, 422-423

Roche, A.F. (1981). The Adipocyte-number Hypotesis. *Child Development*, **52** (1), 31-43

Ross, R., Pedwell, H. and Rissanen, J. (1995). Effects of energy restriction and exercise on skeletal muscle and adipose tissue in women as measured by magnetic resonance imaging. *The American Journal of Clinical Nutrition,* **61,** 1179-1185

Sondike, S.B., Copperman, N. and Jacobson, M. S. (2003). Low carbohydrate diet helps overweight adolescents lose weight safely. *The Journal of Pediatrics,* **142** (3), 253-258

U.S. Department of Agriculture, U.S. Department of Health and Human Services. (1995). *Nutrition and your health: dietary guidelines for Americans*, 4th Edition. Home and Garden Bulletin No. 232. Hayattville, Md.; U.S. Government Printing Office

Van Italie, T.B. (1988). *Topography of body fat: relationship to risk of cardiovascular and other diseases.* Anthropometric Standardisation Reference Manual, Human Kinetics

Willett, W.C. and Ascherio, A. (1994). Trans fatty acids: are there effects marginal? *American Journal of Public Health*, **84**, 722-724

Wilmore, J.H. (1996). Increasing physical activity: alterations in body mass and composition. *The American Journal of Clinical Nutrition,* **63**, S456

Wolfe, B.M. (1995). Potential role of raising dietary protein intake for reducing risk of atherosclerosis. *Clinical Investigative Medicine*, **15,** 127G-131G

Woods, S.C., Seeley, R.J., Porte, D. and Schwartz, M.W. (1998) Signals that regulate food intake and energy homeostasis. *Science,* **280**, 1378-1383

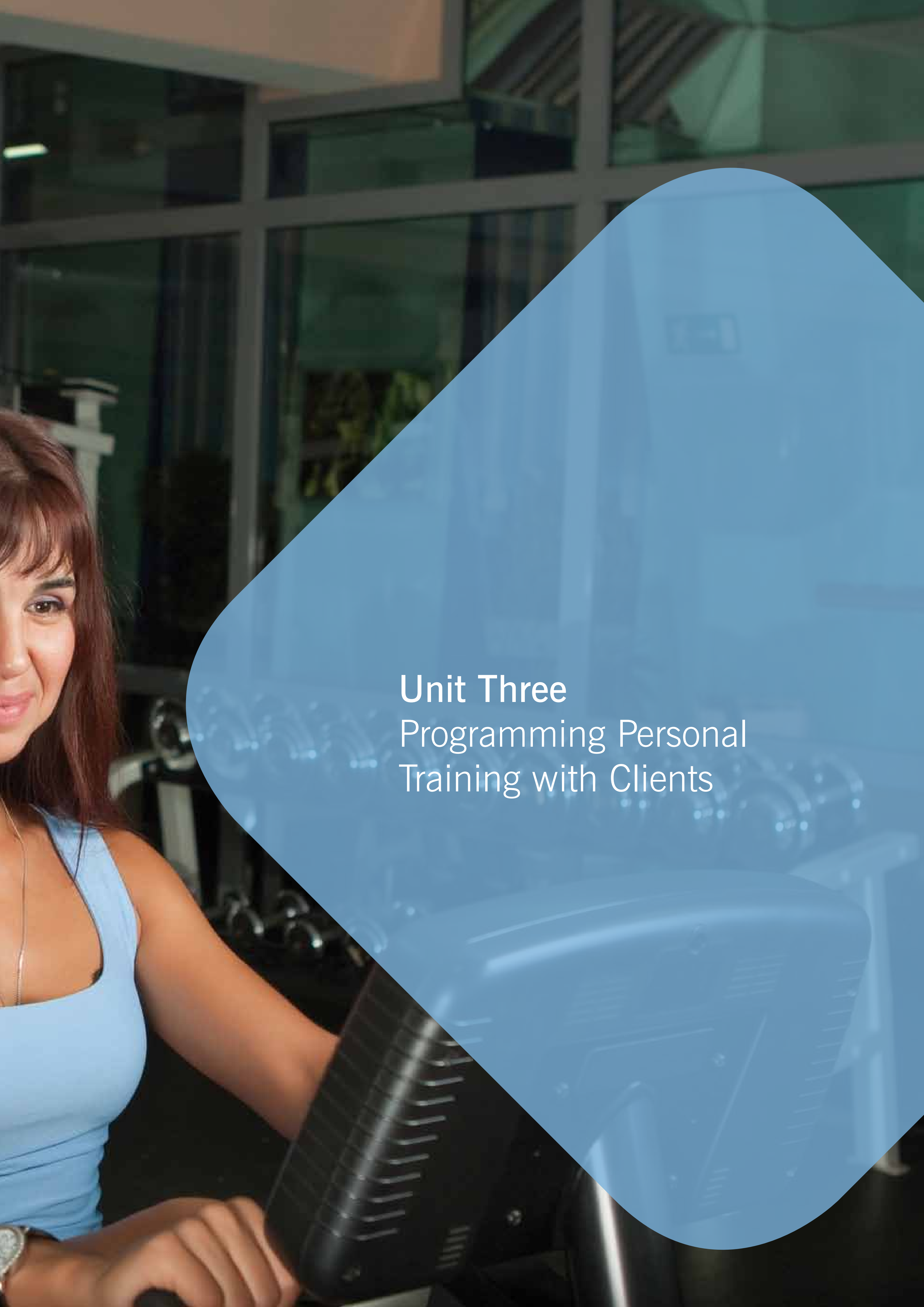
Worthington, V. (1999). Is Organically Grown Food Nutritious?, Price-Pottenger Nutrition Foundation

www.sainsburys.co.uk

www.food.gov.uk

www.news.bbc.co.uk (March 2005). Many labels on food misleading

www.foodlaw.rdg.ac.uk/additives



Unit Three
Programming Personal Training with Clients

Programming Personal Training with Clients

Aim: to provide the learner with the knowledge and skill needed to design, manage and adapt a personal training programme with apparently healthy adults of all ages. This includes reference to 14-16 year olds, older adults, pre and post-natal and disabled clients.

Learning outcomes

By the end of this unit the learner will:

- understand how to prepare personal training programmes
- understand the importance of long term behaviour change for personal training
- understand the principles of collecting information to plan a personal training programme
- understand how to screen clients prior to a personal training programme
- understand how to identify personal training goals with clients
- understand how to plan a personal training programme with clients
- understand how to adapt a personal training programme with clients
- be able to collect information about clients
- be able to agree goals with clients
- be able to plan a personal training programme with clients
- be able to manage a personal training programme
- be able to review progress with clients
- be able to adapt a personal training programme with clients

Introduction to personal training

A personal trainer (PT) is different to a gym instructor in almost every aspect of their fitness training delivery, yet it is still common for their roles to be blurred and misunderstood by gym members and gym staff alike. The roles and responsibilities of the PT and gym instructor are fundamentally different.

Gym instructor	Personal trainer
• gym floor safety • basic exercise programming • maintaining gym etiquette • membership retention • cleaning and maintenance • included in membership costs	• exercise safety • one on one service • long term planning • session by session programming • goal management • health and fitness assessment • individualised delivery • nutritional guidance • lifestyle management • greater accountability • higher skill set • specific niche skills and expertise • fee charged above membership costs

Both the gym instructor and the PT deliver a service within the fitness arena that is needed and valuable. They play their part in the service jigsaw that ensures the members have a positive experience and are able to achieve their health and fitness objectives. Both services are important and needed, but they meet different needs at a different level of service. They are not in competition with one another but instead complement one another to provide a better overall service.

Perhaps one of the reasons the lines have become blurred between these two roles is that it is not uncommon to find health clubs that employ their fitness staff to fill both roles at different times. Seeing the same member of staff spending time on the gym floor as a gym instructor and then later in the day working as a PT can be confusing to the members. It is also difficult for the staff member fulfilling both roles to determine exactly what level of service they provide when in their gym instruction role and what level is retained for personal training. If they give away too much for 'free' in their gym instruction role they will devalue their service as a PT. Conversely, if they are seen to constantly hold back their full knowledge and skills unless members pay additional fees this may frustrate members.

In order to be recognised as a PT in the UK, the PT must currently be recognised by the Register of Exercise Professionals at Level 3, whilst a fitness instructor only requires a level 2 qualification. This means that the PT must have a greater knowledge base than a fitness instructor, be qualified to deal with a larger cross section of the community and train to a higher level of skill and competency than a fitness instructor. This need for greater knowledge and skill, more time and planning, effort and accountability warrant a higher rate of pay and the additional charges most PTs levy on their clients.

Fitness and the health care continuum

Disease	Injured	Medically Cleared and Healthy
Doctor/Nurse	Physiotherapist	Personal Trainer

It is important for the PT to know that they are on a level with other medical professionals; they just provide a different level of service than doctors and physiotherapists. The role of the PT is in trying to optimise the health and fitness of each client and prevent the slide and degeneration towards injury and disease that is so prevalent today.

A doctor's role is to deal with the poor health of those who already have signs and symptoms of disease and physical degeneration. A physiotherapist's role is to assist those suffering physical trauma in the post-operative and/or acute phase of injury and try to restore them to some level of basic physical function. The PT then takes these clients and moves them as far away as possible from the precipice of illness and injury to a place of strong physical functioning and optimal health. Therefore, the PT has a valuable role that is not fulfilled by either the doctor or the physiotherapist, just as the doctor and physiotherapist have valuable roles not fulfilled by most PT's.

The more the PT role on the health continuum is understood the greater value the general public will place on the services offered by appropriately qualified and highly skilled PT's.

PT values and attributes

It takes a certain type of individual to become an exceptional PT. Although most people, if they work hard, can obtain the qualifications to be able to practice as a PT, not all trainers embody the values and attitude necessary to excel. A list of some of the values and attributes that will help lead to success are:

- self motivation
- intuition
- honesty and integrity
- passion and enthusiasm
- creativity
- skilled communication
- unconsciously going the extra mile
- professionalism
- self worth
- service oriented

A PT's core values and attributes will have an effect on all of their actions in delivering an exceptional level of service to their clients. It is these values that will make them unique and stand out from other trainers in their gym, town or region. It is these values and attributes that will attract clients with a similar attitude who will proactively achieve success and whose expectations will be exceeded by the outstanding service provided.

Advantages of personal training

It must be accepted that an individual, no matter what shape they are in does have the ability to improve their health and fitness by themselves, even to very high levels. It is not essential to have a PT in order to achieve. In order to sell personal training services successfully a trainer must fully understand the advantages a PT can provide that will make the health and fitness journey better and therefore, worth the expense. The following offers a series of potential advantages that good PTs may provide to their clients.

- immediate access to a wealth of knowledge and experience
- ability to physically assess health and fitness parameters, then interpret and apply collected data
- achieve effective exercise technique more quickly
- benefit from effective and creative programme planning
- avoid commonplace exercise myths and pitfalls
- benefit from a wider range of training disciplines and modalities
- provide an honest, objective view of current status and progression made
- clear direction and accountability for actions and goals set
- professional record keeping and tracking of actions and achievements
- modifying limiting beliefs and habits that distract from goals
- coordinated goal approach involving nutrition and lifestyle

Depending on the PT's skill set there may be many other advantages that a client will experience by paying for their services. Personal training is becoming a very holistic industry reaching beyond just pure fitness training. It is becoming more common to find trainers with qualifications in massage, sports therapy, corrective exercise, postural alignment, life coaching, neurolinguistic programming (NLP), advanced nutrition, metabolic typing, sports coaching, human biomechanics and many other skill sets that contribute to human health and wellbeing. This wider, holistic approach is offering the PT a vast knowledge base from which to offer unique skills that will be appealing to sub groups of the population.

Linking with other professions

Despite all these additional holistic skills there will likely still be times when a PT will be required to refer clients with issues outside of their professional competence to other relevant professionals.

Many professionals in other fields offer services that complement or link well with personal training. It is essential that a PT should build links and associations with other healthcare and wellbeing specialists to be able to refer clients to people that are known to them. When a PT is familiar with the way other professionals work and they trust their direction it is more likely that the advice, guidance and treatment offered by collaborating professionals will complement one another and lead to a positive, coordinated and balanced change in an individuals life. The following illustration indentifies some of the other professionals that and PT may seek to build a referral and professional network with.

It may be that the PT possesses some of the above skills and therefore does not always need to refer. For example, they may be skilled in stress management and be able to provide this service for their clients. The key is to build up a referral network with professionals who offer vital skill sets not held by the PT.

Goal setting

Once the PT has gathered a sufficient amount of information about a client, they will need to assist in developing a client's goals in order to effectively plan their programme and the actions and strategies needed. This will demand a high level of communication skills in order to help clients identify and define these goals. Communication skills include building rapport, true listening skills, effective questioning, utilising non-verbal communication, clarifying and the ability to negotiate SMART goals. Setting a SMART goal is the final step of effective goal negotiation and can only be completed once all options, barriers and variables have been appropriately discussed. SMART stands for:

- Specific
- Measurable
- Agreeable
- Realistic
- Time

Just simply setting a SMART goal will not guarantee that the client is on the fast track to goal achievement, but SMART goals will serve to focus and keep in mind what needs to be achieved. Once these goals have been set, the client will be required to alter their lifestyle and begin exercising in line with the strategies that were negotiated and discussed.

PT's need to be skilled in writing programmes both for the personal training sessions themselves and those that a client can and will use in any gym sessions when the PT is not by their side. They will also need to affect lifestyle changes that include regular activity, positive sleeping patterns and eating choices.

A PT will need to be in regular contact with their client even when they are not actually scheduled for a session. This may be done by phone, email, text message, during a casual meeting in the club, at classes or on the gym floor. It would be appropriate to discuss with each client what would be their preferred method for the

PT to maintain contact with them during the week and between training sessions. It is also important that the client is able to contact the trainer easily when they need help or direction.

It is vital that goals and behaviour change be viewed by the trainer and the client as long term adaptations that will become routine and habit in the clients life. Often clients are motivated to make a short term adjustment for a specific purpose, such as losing 5kg in weight to feel better in a bikini on the beach in two months time when they go on holiday. Whilst this can be a good initial motivator this does not always bring about permanent changes for the long term management of health and fitness.

Ideally a PT should be developing lifetime habits and changes in people, helping them to discover and define a new way to live. The client should not view the PT as an emergency approach to help them when weight, lack of fitness and health get to the point that they can't bear it anymore and are motivated by fear into action. It is necessary to create positive and enjoyable new behaviours that can form the basis of their life moving forwards.

Training environments

Personal training can take place in a variety of locations, environments and venues so the PT needs to have experience and the skills to make exercise safe for the environment and still be effective. Different environments may require the use of different training kit to exploit the advantages of the environment, different exercise programming, different training modalities and techniques to optimise the clients experience and rate of fitness gains. The types of environment that may be suitable for personal training include:

- the home
- client's garden
- busy gym
- public parkland
- playing field
- athletics track or stadium
- village hall or community centre
- woodlands or countryside
- the beach

Certain environments may provide additional challenges and barriers to training. The trainer will need to consider and overcome these, where possible, to enable training to take place as scheduled. Some of the barriers that might present themselves may include:

- lack of space
- lack of equipment
- adverse weather conditions
- inappropriate terrain
- other people using public space
- pets and animals
- dusty or slippery conditions

Providing these considerations have been taken into account and can be safely negotiated around then a PT will be able to utilise a variety of training environments successfully.

Record keeping

The PT needs to keep good records of their client's progress, condition, adaptations to training, reassessment and any resulting changes in the programme and the reasoning behind them. These notes need to be taken regularly prior to, during and after workouts. Reassessment records and programme cards should be recorded, completed and filed for future reference. These records should also be kept confidentially as required by data protection laws.

Conclusion

The PT must be proficient in communication, client assessment, goal setting, behavioural change, programme design and record keeping. They must also adapt their skills to suit a wide variety of different clients, venues and equipment choices. It is these skills that differentiate a PT from a fitness instructor.

Appraisal and lifestyle analysis

Rationale for conducting a health and fitness appraisal

Most newcomers to exercise are apparently healthy individuals seeking to become fitter and lose weight. For most of these individuals, becoming more active is safe and desirable (ACSM, 2001). Furthermore, individuals who remain physically active are less likely to develop several major chronic diseases such as heart disease, obesity and diabetes. A recent report by the Chief Medical Officer (2004) stated that:

"Physically active adults have a 20-30% reduced risk of premature death and up to a 50% reduced risk of developing major chronic diseases such as coronary heart disease, stroke, diabetes and cancers."

However, for some individual's exercise can actually have the opposite effect. For example; a diagnosed hypertensive may be at risk during physical activity due to already having elevated blood pressure. Consequently, the likelihood of a life-threatening event is increased. Its prudent, therefore, that personal trainers (PTs) understand the potential risks that exercise poses to some individuals.

Exercise risks:

- cardiovascular complications (e.g. MI, cardiac arrest, arrhythmias)
- bronchospasm or exercise-induced asthma
- immune impairment (e.g. resulting in colds, flu, viruses)
- overtraining syndrome (e.g. fatigue, loss of vitality)
- amenorrhoea or dysmenorrhoea
- traumatic injury (e.g. pulled muscle)
- overuse injury (e.g. runner's knee)
- hypoglycaemia
- hypertension or hypotension

PT's have a legally bound duty to minimise the risks and maximise the benefits (also to protect themselves from litigation) of exercise participation. Screening tools should be used to identify individuals who require further medical evaluation before embarking on an exercise programme.

Using industry accepted techniques such as questionnaires, diaries and oral questioning, a client's health and fitness profile can be established. Decisions are then made on each client's readiness for exercise, so the most appropriate action can be taken (Kordich, 2004). In the event of a client being deemed unsuitable for immediate exercise, they can be referred to an appropriate health care professional such as a General Practitioner (GP). It must be noted that, the client will need to seek medical clearance prior to starting an exercise programme.

It is stressed that PT's are not qualified to diagnose any medical conditions or rehabilitate from injury (unless they have a relevant professional qualification). This is beyond the PT's scope of practice set out in the National Occupational Standards released from Skills Active (government agency). In other words, diagnosis or intervention must be supported or supervised by a suitably qualified health care professional i.e. a registered medical practitioner or chartered physiotherapist.

Generally speaking, a health and fitness appraisal should be conducted for the following reasons:

Safety:

- through questionnaires, diaries and oral questioning, clients at high risk (medical contraindications) can be identified
- high risk clients can be referred to appropriate health care professionals
- gain client consent

Programme design:

- test results can be used to establish a set of fitness baselines
- individualised exercise programme can be prescribed

Monitoring:

- provides an opportunity to monitor a client's rate of progress - health/fitness appraisal should be an ongoing process

Total lifestyle evaluation:

- provides an opportunity to evaluate current lifestyle behaviours such as stress, activity levels, occupation and eating habits - consideration should be given to all lifestyle factors, as they will influence the success of any lifestyle intervention programme

Establish rapport:

- provides an opportunity for the trainer to get to know the client and establish a positive connection - successful working relationships are always built on rapport
- provides opportunity to determine an appropriate communication style - showing empathy and understanding to client's personal circumstances

Education:

- educate clients to make informed lifestyle choices - clients must understand the pro's and con's of pursuing certain lifestyle

Professionalism:

- enhances trainer credibility
- provides an opportunity to explain working practices, policies and procedures

Motivation and adherence:

- short, medium and long-term goals can be established and agreed - goals increase focus and raise levels of motivation and exercise adherence

Conducting a comprehensive health and fitness appraisal

In principle, two components make up a health and fitness appraisal. First, an individual's current health and lifestyle status should be classified. Secondly, this information should be used to screen clients before testing physical fitness. The following procedures should be followed.

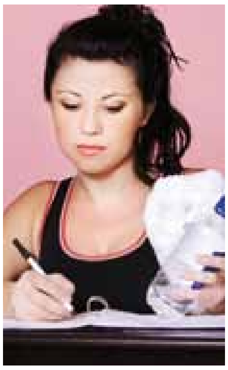
Health evaluation

The purpose of a health evaluation is to identify the presence of disease or health conditions and to assess an individual's disease risk status (Heyward, 1998). Some simple pre-test and test measures to assess current health status can be followed. Based on the results a professional judgement is made whether to refer a client to a more suitably qualified health professional or not. Measures include:

- administering the Physical Activity Readiness Questionnaire (PAR-Q)
- assessing the clients coronary risk profile using CHD risk factor table
- administering medical and lifestyle questionnaire
- performance of static tests

Informed consent

Cient consent must be obtained prior to gathering personal and confidential information, health assessment and testing physical fitness. Consent can be obtained by administering a standard disclaimer. Its purpose is to explain the purpose of gathering the relevant information and the nature of each health assessment and physical fitness test, the risks involved and the benefits expected from each test. In addition, the PT should read through the informed consent form with the client and then ask the client if they have any questions.



Finally, both parties must sign the form before carrying on. This ensures that the client is fully aware that information offered and physical participation is entirely voluntary. It also legally shows that the client understands the risks and benefits of subjecting themselves to analysis and testing and that they accept responsibility for their participation. A sample 'informed consent' form can be found in the appendices.

Medical history and PAR-Q

The Physical Activity Readiness Questionnaire (PAR-Q) developed by the Canadian Society for Exercise Physiology is a popular screening tool. When used in its unadulterated form, the PAR-Q is effective in identifying medical contraindications to exercise that the client is currently aware of. The questions are carefully worded in such a way that a healthy individual will answer 'no' to all the questions. If the client answers 'yes' to any of the questions then medical clearance should likely be sought from their GP before exercise begins.

Any health complaints that have not been diagnosed or are outside of the client's awareness, for example elevated blood pressure, may not be flagged up through a questionnaire. Therefore, it must be recognised and accepted that questionnaires, while valuable, are limited in their scope to what the client knows and is willing to share about their own health.

Coronary risk factor profile

Using the 'primary and secondary' risk factor table PTs can quickly assess the client's current coronary risk status. The client can then be assigned to one of three categories, these are:

- medical referral - clients in this category have a serious condition or serious medical risk factor for coronary heart disease (CHD). They should always be referred to their GP. However, the majority of clients in this group will benefit from a regular exercise programme. It is advisable to write a letter to the client's doctor outlining assessment results. In most cases, the trainer will know much more about exercise than the client's GP.

- special attention - clients may be placed into this category for several reasons. Clients present with several factors that together contribute a risk for CHD. Or, it may simply be because they are older or have not exercised before. Many factors have to be taken into consideration. It becomes a matter of personal judgement whether or not to refer.

- fit and healthy - clients in this group have no health problems, no risk factors for CHD and have been following a regular exercise programme for at least two months. This group includes most sports specific athletes.

Criteria for medical referral

There are four criteria for referring a client to their GP. These are as follows:

- instant medical referral
  - any factor in the 'medical referral' category of the primary and secondary risk factor table
  - any diagnosed metabolic, pulmonary or cardiovascular disease
  - signs or symptoms of a pulmonary or cardiovascular disease

- several measurements require special attention
  - for example, BP 140/90, current smoker and positive family history of CHD

- doubt or uncertainty
  - doubt or uncertainty regarding any aspect of the client's health. The PT should play safe and refer

- client preference or doubt
  - if the client expresses a desire to be medically referred before starting an exercise programme, again play safe and refer

Referring a client to another health care professional

If a referral has been identified, the client will need to seek medical clearance (GP or physiotherapist) before carrying on. However, it's important the client is kept in the loop and doesn't just disappear out of the door never to return. In other words, some form of follow up procedure is needed. Furthermore, networking with other health care professionals is recommended if PT's are to best serve their clients.

Standard referral letters can be drafted (with the client's consent) or contact can be made direct. Any letter should contain results and comments on areas of concern that have been identified through testing. On a final note, schedule an alternative appointment and follow this up with a phone call. There are some conditions that may be discovered during a health appraisal that should only be taken on by the trainer if they have further specific qualifications to manage these disorders even after medical clearance is provided. Such conditions include:

- cardiovascular disease
- stroke
- cancer
- type 1 and 2 diabetes mellitus
- Parkinson's or Alzheimer's
- multiple sclerosis
- depression
- dementia

These specific skill sets can be obtained and a trainer becomes qualified in using exercise to help manage the above health conditions. In the meantime, the trainer needs to focus on what conditions or health concerns they can still provide benefit for after medical referral has been obtained. The tables below provide guidance on what factors should be used to justify medical referral.

Primary risk factors (at risk of disease)		Normal	Special attention	Medical referral
Blood pressure	SBP & DBP (mmHg)	≥ 139 and ≥ 89	≥ 140 or ≥ 90	≥ 160 or ≥ 100
Body composition	Body fat (% bodyfat)	Male 18-25% Female 25-30%	<6% or 26-30% <14% or 31-40%	> 30% > 40%
	Waist-to-hip ratio (waist ÷ hip circumference)	Male <0.85 Female <0.75	>0.9 >0.8	
	BMI (weight ÷ height_)	18.5 – 24.9kg/m^2	25 – 29.9 kg/m^2	30 + kg/m^2
Cholesterol	Total Cholesterol (mmol/L)	> 5.2	> 5.2	> 5.7
	LDL Cholesterol (mmol/L)	≤ 3.4	> 3.4	
	HDL Cholesterol (mmol/L)	≥ 0.9 (or 25%+ of Total)	< 0.9 (or < 25% of Total)	
Smoking		Non-smoker	Current smoker (1+/day) or quit within last 6 months	
Exercise (physical activity levels – for a minimum of 8 weeks)		≥ 30+ mins CV 3-5 times/week.	< 30 mins CV 3-5 times/week.	
Family history	MI or sudden death in 1st degree relative. male < 55 years or female < 65 years	No family history	Positive family history	
Impaired glucose fasting (diabetes)	Fasting blood glucose (mmol/L)	≤ 6.0	6.1-6.9	≥7.0 Diabetic

Secondary factors		Normal	Special attention	Medical referral
Age		Male $<$ 45 years Female $<$ 55 years	Male $\geq$ 45 years Female $\geq$ 55 years	$\geq$ 160 or $\geq$ 100
Resting heart rate (beats per minute)		$\geq$ 89 bpm	90-99 bpm	$\geq$ 100 bpm
Alcohol consumption	Units of alcohol per week	Male $\leq$ 21 units Female $\leq$ 14 units	Male 29-42 units Female 22-35 units	Male $\geq$ 43 units Female $\geq$ 36 units • cirrhosis
Lung function	Forced Expiratory Ratio (FER)	Within predicted range values	Below predicted range values	Known pulmonary disorder unless under control
Conditions		Free of all conditions	• allergies • anaemia • bleeding trait • cancer • colitis • epilepsy • mental illness • peptic ulcer • pregnancy • thyroid problem	
Medication		Not on medication	• diabetic pill • epilepsy medication • any other medication	• heart medication • diuretic • insulin • nitroglycerin • digitalis

Lifestyle analysis

A lifestyle questionnaire and consultation asks further questions around the clients personal and family health history. Additional information is obtained such as current physical activity levels, exercise history, likes and dislikes, occupational factors, diet, stress levels, sleeping patterns, goals, motivation levels and barriers to participation. Remember that this type of questionnaire is subject to a client's interpretation and willingness to share private information about their lifestyle to a health professional. It may be that their concerns or embarrassment about how they live in comparison to how they perceive the PT to live will restrict the accuracy and honesty with which information is shared in a lifestyle questionnaire.

Dietary intake and eating habits

Dietary habits significantly impact on a person's health, training and performance. Dietary behaviour can be easily monitored through the use of a food diary. The client is asked to truthfully record all foods and liquids consumed generally over a seven day time period. Furthermore, the client should record time of consumption, energy levels up to two hours after consumption and emotional state at the time and after consumption. The PT can then easily assess dietary patterns and behaviours such as over or under consumption, reasons for consumption (i.e. peer pressure, boredom and anxiety), macronutrient intake and available energy levels. Whilst food diaries are still not 100% accurate and are limited by the clients ability to correctly record their food intake, they tend to provide better and more accurate information than a dietary questionnaire.

It is noted that poor nutritional habits can have a major effect on all facets of a person's health; for example, poor concentration, altered emotional state, lower energy levels, increase in the susceptibility to outward signs of stress and poor sleep quality. Leading on from this point, poor sleep quality combined with high stress levels suppresses the immune system increasing the likelihood of illness and disease. Failure to assess a client's nutrition will limit the amount of success achieved with clients.

Physical activity patterns

Current and past physical activity patterns can be easily recorded using a diary or questionnaire. Once again diaries are normally completed over a seven day period. The client is asked to truthfully record all physical activity including duration, frequency, type of activity or exercise (e.g.. free weights, machines or cardiovascular equipment), leisure time activity (e.g. walking, golf, gardening and sports) and occupational activity (active or sedentary).

Beyond the scheduled exercise sessions that a PT is going to plan for a client, daily physical activity should be encouraged. This does not need to be intense and difficult to complete, but should increase heart rate above resting levels and get the body moving in some way. Daily walks, household cleaning, gardening, using the stairs instead of lifts and escalators, playing with the kids, active hobbies and leisure time should be discussed and factored into a client's lifestyle and regular routine.

Occupational analysis

Evaluation of a client's occupation can provide the PT with valuable information on occupational physical activity and postures. Work postures are either dynamic or static. For example, a 'scaffolder' has to adopt a variety of dynamic postures including bending to pick up objects, lifting objects from the ground to overhead, and rotating side to side, often performed in a restricted space. On the other hand, an 'office worker' is likely to remain seated for most of their work day adopting a fixed and flexed posture at their desk.

Smoking and alcohol use

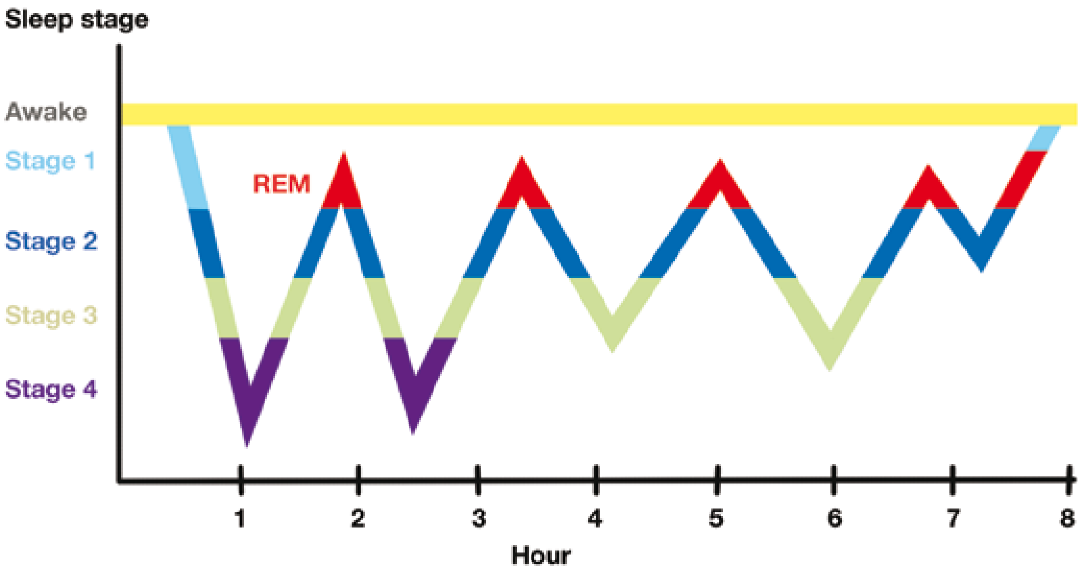
Both alcohol and especially smoking have a negative impact on overall health (Heyward, 1998). PTs need to try and understand the reasons for smoking or drinking and monitor the amount of consumption. Both behaviours are used as coping strategies (negative) to deal with aspects of one's lifestyle, especially during times of great stress. It is very common that people underestimate the amount of alcohol that they ingest on a regular basis. It may be better to try and ask the client to recall the beverages they consumed in the last week and for the trainer to determine the number of units consumed. Whilst this is still an estimate, it is likely to be more accurate than allowing the client to estimate their weekly intake.

Sleeping patterns

Sleep is one of the most important factors affecting a person's health; unfortunately, it is often considered the least by the PT. In our modern technological age, time is at a premium. Night time used to be reserved for relaxation and sleep, however, people all over the world now work, travel, exercise and socialise during the night time hours.

The National Sleep Foundation (NSF) states that sleep is a basic human need and is just as important for good health as diet and physical activity. A good night's sleep allows the body to wake up fresh and invigorated, ready to face the coming day's challenges. On the other hand, too little sleep results in daytime drowsiness, inability to concentrate, increased risk of accidents and reduces overall productivity and performance. In the long-term, sleep deprivation has been linked to premature aging, digestive disturbances, psychological problems, behavioural disturbances and a myriad of chronic diseases, which include lowered immunity (Nelson et al., 2005), insulin resistance, obesity, diabetes, heart disease (NSF) and even cancer (Stanford School of Medicine, 2004).

Sleep is often considered a passive activity, but while the body rests the brain is active. During sleep the body passes through 5 stages: stages 1, 2, 3, 4 and REM (rapid eye movement). Stage 1, the lightest form of sleep can be considered the transition from drowsiness to sleep (during this stage the body can easily be woken); stage 2 to 3 are considered the transition to stage 4 the deepest form of sleep. Deep sleep coincides with the release of growth hormone (especially in children and young adults), subsequently, deep sleep allows for physical repair and regeneration of many of the body's cells. The final stage of sleep is REM which is thought to stimulate the brain regions used in learning. REM sleep is especially important during infancy. Scientists suspect that this is why infants spend much more time in REM sleep than adults. Sleep stages progress in a cyclic fashion from stage 1 to REM, then the cycle is repeated. A complete sleep cycle is thought to take between 90 and 110 minutes.



The body is naturally set to a 24 hour clock, known as the 'circadian rhythm' from the latin 'circa dies' (about one day). However, sunlight provides a powerful regulator resetting the internal clock in line with the 24 hour period. The internal biological clock is fundamental to the survival of all living organisms, influencing hormones that play a role in sleep and wakefulness, metabolic rate, and body temperature. The source of this internal biological clock is called the suprachiasmatic nucleus (SCN).

The SCN controls important functions that are synchronised with the sleep/wake cycle, including melatonin levels, body temperature, hormone secretion, urine production, and changes in blood pressure. A powerful example of the biological clock at work is the feelings associated with 'jet lag.' After crossing several time zones the body's internal biological clock is out of sorts with the new time zone often resulting in uncontrollable drowsiness throughout the day.

Many other factors influence the amount and the quality of sleep, including:

- age – infants need more (12-14 hours) compared to adults
- caffeine – coffee, tea, and cola drinks
- alcohol – inhibits deep sleep
- smoking – experience withdrawal during the night
- high stress levels
- certain foods
- some medications – diet pills, decongestants and antidepressants

Sleep scientists generally agree that most adults need between 7 to 8 hours a night. Getting too little sleep creates a sleep debt (which is like being overdrawn at a bank). Eventually, the body will demand that the debt be repaid. If after lying down a person falls asleep within 5 minutes then they are probably sleep deprived. Consequently, judgement, reaction time and many other physiological functions are impaired. However, it is common for people to become accustomed to a sleep depriving schedule. This is an important consideration for those workers who work long hours or night time shifts such as fire fighters, industrial workers and doctors.

The evidence in support of sleep providing health and longevity is overwhelming and should be considered and analysed as part of the client's overall lifestyle intervention programme. Sleeping patterns can easily be assessed using a sleep diary (appendix). The following strategies can be offered to improve sleeping patterns:

- set a schedule or time for sleep
- exercise (however, avoid exercise to close to bedtime)
- avoid activating the brain before bedtime
- avoid watching TV in bed (better still remove it completely)
- take a warm bath
- reduce stressful activities
- the bedroom should be in complete darkness (black out blinds)
- avoid bedside digital display clocks
- avoid caffeine less than six hours before bed
- avoid nicotine, and alcohol (alcohol and nicotine disturb sleep)
- relax before bed
- don't go to bed too full or too hungry
- sleep until sunlight
- control the room temperature (lower temperature improves sleep)

Performance of static tests

Conducting static tests provides important information regarding the client's current health status. Test results will dictate the outcome. The following static tests can be administered; however, careful attention must be paid to the order of test administration as inappropriate order will lead to inaccurate results.

- resting heart rate (RHR)
- blood pressure (BP)
- body composition
- skinfold
- bio-electrical impedance
- body mass index (BMI)
- waist to hip ratio
- lung function

A complete explanation of how to perform the static tests and analyse test results can be found in the appendices section of the manual.

The trainer should select what tests are important and relevant to the individual rather than just routinely performing each and every static test. Attention should be given to test order especially in relation to blood pressure to ensure that the client has been relaxed and still for 5-10 minutes prior to testing. For this reason, it is common to carry out blood pressure first after a period of seated discussion and consultation. A skilled trainer can determine very accurate and reliable information through the appropriate application of static health tests. They can be very useful to guide the PT in improvements in key indicators for health as the client progresses.

Testing physical fitness

The purpose of testing physical fitness is to establish a client physical fitness profile. Each test allows the PT to assess a specific component of physical fitness and record the client's strengths and weaknesses (Heyward, 1998). Data from specific tests is assessed against standard reference tables for each component of physical fitness. Current fitness baselines are then established, which are then used to write a client specific exercise programme.

Physical fitness tests include:

- power
  - ✓ vertical jump (VJ)
  - ✓ standing broad jump (SBJ)
- muscular strength and endurance
  - ✓ sit-up
  - ✓ back extension
  - ✓ repetition maximum tests
- cardiorespiratory
  - ✓ Balke treadmill
  - ✓ Multistage fitness test
  - ✓ Cooper 1.5-mile run
  - ✓ Cooper 3-mile walk
  - ✓ Queens College step
  - ✓ other ergometer tests
- specific range of movement (ROM)
  - ✓ soleus and gastrocnemius
  - ✓ hamstrings
  - ✓ quadriceps and hip flexors
  - ✓ adductors
  - ✓ pectoralis major
  - ✓ latissimus dorsi

A complete explanation of how to perform the fitness tests and analyse test results can be found in the appendices section of this unit.

Principles of health and fitness appraisal

Test appropriateness

Select tests that match the needs, goals and capabilities of the client. Not all tests are suitable for all clients. For example, a previously sedentary client will need to develop cardiorespiratory fitness. Selecting a test such as the vertical jump test (VJT) would be totally inappropriate and potentially high risk. In this case, since fitness levels are low a sub-maximal cardiorespiratory test would be more suitable. Conversely, for advanced clients participating in team sports such as netball and basketball, a sub-maximal test would be unsuitable, whereas the VJT would be most relevant.

Test validity and reliability

To accurately assess the client's health and fitness status, tests should be selected that are valid, reliable and objective (Heyward, 1998). The following test guidelines should be followed to ensure test validity and reliability:

- equipment - equipment used should be of good quality, regularly inspected and well maintained

- client - before testing begins, clients should be instructed to follow a series of guidelines or pre-test procedures. It is imperative for test accuracy and thus validity, that the trainer ensures each client arrives in a 'neutral state' (variables reduced to a minimum). Failure to do this will void the test. This can be achieved by listing the pre-test procedures on the back of an appointment card to be handed to the client on the initial booking. Be sure the client has followed the guidelines prior to testing. Consider the following:

  1. Consumption:
  - avoid heavy meals less than three hours prior to the test
  - avoid drinking excessive alcohol during the day before the test and altogether on the day of the test
  - avoid drinking coffee, tea, cola or any caffeinated beverage two hours prior to the test
  - avoid smoking for at least two hours prior to the test

  2. Action:
  - avoid exercising or any form of strenuous physical activity on the day of the test
  - have a good night's sleep the evening before the test
  - avoid using a jacuzzi, sauna or sunbed less than two hours prior to the test

  3. Medical:
  - avoid or cancel the assessment if you have a temperature or feel unwell
  - bring with you any current medication e.g. inhalers

  4. Clothing:
  - wear appropriate clothing e.g. trainers

- timing - time of day can influence the results since client temperature, hydration levels and activity levels change throughout the day. A female client's phase of menstrual cycle can influence the accuracy of results due to fluctuation in body temperature and fluid levels. If possible, the time of day should be kept constant. If not, this must be recorded and taken into account.

- environment - temperature (and humidity) affects the heart rate response to exercise. Ideally, environmental factors should be kept constant from one assessment to another. If this is not possible, temperature should at least be recorded and taken into account.

Customer service

The highest levels of professional service should be demonstrated at all times throughout the appraisal process. Good duty of care involves informing the client of the sensations and feelings to be felt with each test and making sure the client is comfortable at all times. Refer to the trainer code of ethics for working practices.

Indications for stopping a fitness test

During test administration PTs must stay vigilant at all times. Tests should be stopped immediately and clients referred in the following circumstances:

- onset of angina-like symptoms
- significant drop (20mmhg) in systolic blood pressure or a failure of the systolic blood pressure to rise with an increase in activity
- excessive rise in blood pressure: systolic pressure >260 mmHg or diastolic pressure >115 mmHg
- signs of poor perfusion: light-headedness; confusion; ataxia; pallor; cyanosis; nausea; or cold, clammy skin
- failure of the heart rate to increase with increased exercise intensity
- noticeable change in heart rhythm
- client requests to stop
- physical or verbal manifestations of severe fatigue
- failure of the testing equipment

General indications for stopping exercise testing low-risk adults (ACSM, 2001)

Other documentation

Client/trainer agreement: this is a finalised agreement between client and trainer detailing the working practices and responsibilities associated with both parties (appendix). Details should include the service being offered, the parties involved, a working time line (e.g. 3, 6 months or longer), the costs and payment process and finally details of cancellation procedures. Read the agreement to the client and ask if they have any questions. Finally, both parties are to sign. This will ensure clarity on both sides, which is fundamental to a professional relationship.

Goals inventory: this allows the PT to identify the client's objectives and their current levels of motivation. Knowing a client's goals allows the trainer to adopt the most appropriate strategy. For example, test selection and the style of communication. In addition, goals give focus and increase motivation.

Re-evaluation

A vital element of the appraisal process is ongoing reassessment and evaluation of progress. The PT should plan in specific dates that fit in with the time periods for short and medium term goal achievement to test and evaluate various indicators that the goals set are actually being accomplished. An evaluation may cover health markers such as blood pressure, physical shape and body composition, physical fitness as assessed through various fitness tests, nutritional and dietary changes and finally behavioural and lifestyle habits and routines.

Prior to any checks or testing being performed it can often be very useful to gain feedback from the client on how they feel they are doing and what progress they have made in relation to their goals. This can serve as a platform to build upon throughout a re-evaluation. The main objective is to strengthen a client's motivation and adherence to the fitness programme, diet and lifestyle direction that has been initiated and to continue moving towards their goals.

At the end of a review session the original objectives should be discussed, praise offered for those that have been achieved, adjustment of ongoing objectives set if necessary and new short or medium term goals set in relation to the overall long term objective. These tweaks and adjustments to the goals should be formulated in conjunction with the client and mutually agreed as part of the process. Assessment results, new client information and revised goals and objectives should be accurately recorded and stored confidentially in the client's portfolio for future reference. Changes to training should continue to be monitored between evaluations as these formal reassessments may be spaced some 8-12 weeks apart.

Following a review of the client's performance a trainer will need to adjust their fitness programme to provide progression or regression dependent on the outcome. This will help the trainer to 'tune in' to the client's ability to adapt and to provide the correct level of stimulus to bring about optimal growth. Alterations to a fitness programme may not only involve obvious changes like variation on the number of sets, repetitions and weight, but may also include changes in the equipment used, the mode of training, the training environment, the complexity of movement and the pace of movement.

The introduction of changes to a fitness regime still needs to take into account the personal, family and employment circumstances of the client.

Client confidentiality

In 1998 the Data Protection Act (DPA) was introduced to give and protect the rights of individuals who have personal information held about them, and places obligations on those individuals (data controllers) with legitimate reasons for recording, processing and using personal information. This means data controllers need to justify the purpose for which personal information is to be processed, and the benefits that will be gained by the client.

Since PT's will need to collect and analyse client personal information they have a 'legal and ethical duty' to document, organise and store personal information obtained from clients during a personal training session and should be in line with good information handling practice. This is vital if the trainer wants to protect themselves and their client. By recording clear and accurate information, the trainer will be able to provide evidence of proof of service given. This is especially important if the standard of service is under scrutiny with the prospect of an impending lawsuit.

To comply with the DPA (the law) the PT must obey two obligations when holding personal information. Firstly, PTs need to follow the eight principles of good practice. These state that data must be:

1. Fairly and lawfully processed
2. Processed for limited purposes
3. Adequate, relevant and not excessive
4. Accurate and up to date
5. Not kept longer than necessary
6. Processed in accordance with the individuals rights
7. Secure
8. Not transferred to countries outside European Economic Area unless the country has adequate protection for the individual

For personal information to be fairly processed, at least one of the following conditions must be met:

1. The individual has consented to the processing
2. Processing is necessary for the performance of a contract with the individual
3. Processing is required under a legal obligation (other than one imposed by the contract)
4. Processing is necessary to protect the vital interests of the individual
5. Processing is necessary to carry out public functions e.g. administration of justice
6. Processing is necessary in order to pursue the legitimate interests of the data controller or third parties (unless it could unjustifiably prejudice the interests of the individual)

The client has several rights stated by the DPA over all personal information held by the data controller (personal trainer), these include:

1. The right to subject access – clients have full access to personal information held about them, whether it is recorded electronically or manually
2. The right to prevent processing – the client can ask the data controller not to process personal information held if they feel it causes distress or harm to them or others
3. The right to prevent processing for direct marketing – the client can ask the data controller not to use personal information for direct marketing purposes
4. The right to compensation – the client will be able to claim compensation from the data controller for damage and distress caused by the misuse of personal information held about them
5. The right to rectification, blocking, erasure and destruction – clients can apply to the courts to rectify, block or destroy information held by the data controller if they feel the data controller has misused/or based their opinions on inaccurate information

6. The right to ask the Information Commissioner's Office (body to promote and enforce the DPA) to assess whether the Act has been contravened – clients can ask the commissioner to make an assessment if they feel that their personal information has not been processed in accordance with DPA

Additional to the above, consideration should be given to the following:

- writing is legible
- writing is in black permanent ink
- information is in a clear and logical format
- all entries are dated and signed
- any corrections must be initialled and dated
- correction fluid must not be used
- any advice given to the client is recorded within 24 hours
- all subjective and objective information is recorded
- the trainer's full signature must appear on each page
- client records are stored securely in a lockable fire proof cabinet at all times
- all records are confidential and not accessible to third parties
- client records are retained for a minimum of eight years
- client records are only released with the client's written permission

The second obligation states that data controllers must inform the Information Commissioner about themselves, the kind of information they intend to hold and the purpose for which that information is to be processed. A form can be completed online at www.dpr.gov.uk. The notification form should then be printed off and sent by post with a fee of £35 to:

Notification Department, Information Commissioner's Office, P.O.Box 66, Wilmslow, Cheshire, SK9 5AX

Consultation and goal setting

The consultation is the first major interaction between trainer and client and so it is vital that it is conducted professionally and effectively. The PT will need to implement their interpersonal and communication skills. This includes a wide variety of skill sets including rapport building, utilising body language, verbal construct, listening and questioning skills. They will also have the chance to showcase their skills and demonstrate their knowledge whilst still having a friendly, caring and motivated attitude. These attributes and skills will likely appeal to the larger majority of clients.

Preparing for consultation

To ensure success the trainer must prepare for the consultation with meticulous detail. The trainer needs to consider four areas:

- the environment
- the consultant
- the client
- the process

1. The environment

It will be important that the environment is suitable for helping create the appropriate consultation climate. The room should make the client feel relaxed and at ease. They should be able to communicate with the trainer in private and be sure they will not be interrupted. An area should be prepared for the purpose of conducting consultations, if this is possible. The following are suggestions to consider when preparing the environment:

- private room
- clean and tidy
- well decorated
- bright colours
- appropriate pictures
- free from distractions
- no barriers (such as a desk between people)
- comfortable chairs at an appropriate angle (about 90 degrees) and appropriate distance

In summary, make sure the consulting room is as welcoming as possible. If the environment is too hot or too cold, noisy or stuffy then it makes concentration difficult for the PT and the client. Disturbances will affect the flow of the session so make sure there are no disturbances from telephone calls, e-mails or any visitors.

2. The consultant

As the consultant the PT will need to consider the image they portray and the impression they want to give. The PT will need to spend some time preparing, in terms of clothing, and considering the skills they are going to implement. Clothes and personal presentation are all part of the client's surroundings so the PT must ensure they dress comfortably and professionally. PTs will be judged on the clothes they wear and the image they present. It may be superficial, but it is worth taking care to create the right impression.

The PT will also need to spend some time putting themselves in their client's shoes and considering how they may be feeling, while making sure they are feeling in a positive and confident state themselves. The successful consultant should have the following characteristics:

- good communication skills
- positive body language and good posture
- be genuine and empathetic
- professional
- organised
- able to maintain confidentiality
- non-judgemental

3. The client

In order for the client to get the most out of the consultation and feel at ease before the consultation it is necessary to give them certain information and instructions to prepare themselves prior to the appointment. The PT should take measures to ensure that the client is prepared in the following ways:

- appropriate clothing for both static and dynamic testing
- have completed pre-consultation paperwork (e.g. PAR-Q, questionnaires)
- arrive in a neutral state for appointment:
  - ✓ no caffeinated beverages for 2-3 hours previous
  - ✓ no smoking for 2-3 hours previous
  - ✓ no alcohol 24 hours previous
  - ✓ no exercise 2-3 hours previous
  - ✓ full nights sleep before
  - ✓ minimal stress and relaxed

Creating the climate for consultation

The climate created is clearly under the PT's control. This first meeting is the beginning of what may be a long and productive relationship. The client is about to make a commitment to changing their life for the better with the PT's guidance. The climate established should be conducive to developing rapport with the client and letting them open up and feel comfortable giving information about themselves. Rapport comes from a genuine attempt to understand the other person on their own terms, to see the world from their point of view and imagine what it would be like to 'walk a mile in their shoes'.

Attention to detail is important; the PT should make sure there are no interruptions, that the room is laid out correctly to avoid barriers, that the seating is comfortable and that the PT uses open body language and maintains good eye contact.

Developing rapport

The ability to quickly develop rapport with a client is vital in setting the mood and establishing a climate that is conducive to open communication. The word 'rapport' implies a harmonious relation or emotional affinity between two or more people. It is common for there to be a little tension or awkwardness between two people when they first meet. It is the responsibility of the trainer to reduce that tension and help the client to feel comfortable and at ease. This is where rapport building skills really come in useful. The most important aspects of successfully building good rapport are positive body language and the way that we say things, much more so than what we actually say.

Once good rapport has been established it will be much easier to discuss the relevant information and explore concerns and barriers than it would be if the client was still feeling awkward. Rapport building is not only a skill needed for the initial ice breaking, but should be continually weaved into the whole consultation process to improve the professional relationship and continue to overcome communication barriers.

Developing skills to conduct a consultation

Conducting an effective consultation is not something that will just happen. It needs to be worked on; in particular the skills to work on are questioning, listening and communication oriented.

Questioning:

"I keep six honest serving men, they taught me all I knew: their names are What and Why and When and How and Where and Who." Rudyard Kipling

A key skill in communicating with the client is learning how to construct and appropriately utilise a variety of questioning skills. The aims of good questioning are:

- to be able to draw appropriate information out of the client
- to encourage two way communication with the client
- to further explore issues, concerns and barriers
- to clarify or confirm information already shared

The quality of the information received depends upon the quality of the question asked. Questions will take on different forms depending upon the information required. There are many different types of questions; the main three categories used are as follows:

- closed questions
- open questions
- indirect questions

There are also questioning techniques, which are often considered less effective – these include:

- ill-formed questions, such as leading and loaded questions
- double bind questions
- multiple questioning

Closed questions are those that can be answered as 'yes' or 'no' or by a short phrase. They will be useful to obtain facts or clarify an issue and often start in do, is, are or have. For example:

- are you ready to start?
- where do you live?
- is that a good option for you?
- have you tried this before?

Open questions will require a more lengthy response from the client that may need to be thought over first. It is imperative when asking open questions to allow the client time to consider their response, so do not be afraid of a brief silence. Open questions will invite the client to enter the conversation and are used to explore an issue and gain more detailed information. They will often promote discussion, thought and reflection. They may start with how, what, or why thus avoiding a one worded response. For example:

- how has your training schedule gone this week?
- what free weight exercises do you enjoy?
- why are you keen to follow that particular training style?

Indirect questions are a softer way of gaining information from a client and often feel less intrusive and to the point. These questions tend to soften the approach with a short preparatory phrase that leads into the question. They can also be used to gain more personal information and help the client feel more comfortable in sharing with the trainer. For example:

- I was wondering what you are trying to achieve through your current training regime?
- I am pleased to hear of your progress so far and would be interested to know what training you do on a weekly basis?
- that is fascinating! I would really like to know what you think about interval training as a possible solution?

Leading questions are those that direct the client towards the type of response the PT would prefer to hear and make it difficult to disagree. Often these type of questions are asked unintentionally as a result of not taking the time to construct the question better. For example:

- don't you think that is the best way to train?
- why don't you book in for ten sessions?
- wouldn't it be better to train outdoors today?

These type of questions have little purpose as they do not produce clear and open responses and the kind of information that is valuable to us.

Loaded questions by design demand a certain answer by pre-empting the actual question with a brief statement that sets the questioners views and intent and as a result makes disagreeing seem illogical or discordant. For example:

- everyone is coming to this brilliant class, why don't you?
- I know you'd love this glute exercise, shall we try it?
- this technique always reduces excess appetite, do you want to try it?

Double bind questions limit the client to only two options and as such restrict their ability to answer freely. Sometimes these questions have a place in the consultation if used carefully.

- would you like to train before or after work?
- would you like to use the treadmill or the rower?

Multiple questions actually have several queries asked within the same sentence. They usually require several different answers and as such can be confusing for the client. It is common that these questions are asked because the trainer realises half way through asking the first part of the question that they weren't forming a clear question so they triy to reword it, or think of a follow up question and add it to the first. For example:

- why do you need a personal trainer and what attributes would that trainer need to have?
- so what gets you going first thing in the morning, what motivates you in terms of exercise and activity?

Guidelines for questioning:

- the best questions tend to be short and simple
- make sure the purpose of the question is understood
- construct questions to find out information of value from the client
- questions need to serve the client's interests and needs

The PT also needs to keep the following guidelines in mind when constructing questions:

- emphasise open, closed or indirect questions to achieve the aim
- use words that match the language style the client uses
- be encouraging and supportive when asking questions; avoid interrogation
- be prepared for and allow pauses for thought
- positively acknowledge their responses. Use verbal and non-verbal methods (but don't over do it)
- if the client is struggling then clarify your question

Listening skills

> *You have two ears and one mouth because you should listen twice as much as you speak. Listening is a true art.*

Listening is the second half of oral communication and people will like to talk to the PT if they seem to them to be a good listener. Active listening is an important skill to master. It is all about paying attention to the client:

> *"Attention is one of the most precious commodities in the world. You cannot command it. It can only be given. We feel less alive, less energetic, when we do not get enough attention. Attention is vital to our psychological well-being as air and water are to our physical well-being."* O'Connor (2004)

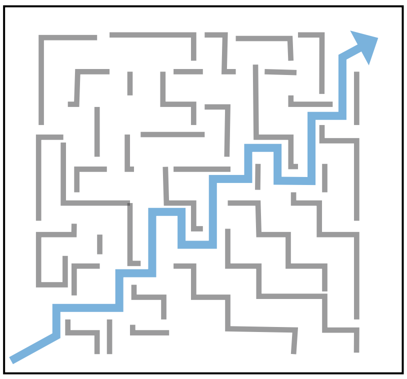
As the PT listens they also need to observe: facial expressions; gestures and posture as these give messages and show how a person feels.

The following key points will help in developing listening skills:

- when preparing to listen, clear the mind of thoughts as it is not possible to listen and think at the same time
- avoid pre-judgement and jumping to conclusions before hearing what they say (we often pre-judge on looks, occupation or clothing)
- keep an open mind and appreciate the speaker's point of view even though it may not be your own
- establish eye contact, but break eye contact occasionally so as not to make client uncomfortable – time these with natural pauses in speech
- watch for non-verbal signals, such as posture, gestures and tone of voice. Notice any disparities in what is said and how it is said. Such as 'I am really happy' said without smiling
- pick out the main points and even make brief notes
- avoid interrupting their flow. Keep questions in mind and ask when they have finished
- avoid distracting with gestures and fiddling
- give full attention and stay switched on
- give feedback by nodding, smiling, and occasional words or sounds of encouragement
- restate and clarify when needed to be sure you have understood them correctly

4. The process

Goal setting



A significant part of any verbal consultation is and should be focused on gathering the needed information from the client. This establishes the client's current position or 'point A' so we can best determine how to get to 'point B.' Goal setting is the process of defining exactly where 'point B' is so that both the trainer and client can focus their efforts on moving in the right direction. Despite the common phrase, 'the shortest way between two points is a straight line', the path to achieve a client's goals and objectives usually has a few twists and bumps along the way. It is important that these are navigated correctly to keep the focus on achieving the goals that were determined from the outset.

One of the most common ways of setting suitable objectives is to use the SMART acronym. This simply reminds us of the key elements in writing and recording an effective goal. These individual elements are:

Specific – goal must be clear and concise
Measurable – must be a way of clearly comparing start and finish points
Agreeable – both parties need to be in agreement
Realistic – specific objective must be attainable within the time frame set
Timed – a exact, agreed amount of time must be set to focus efforts

In order to fully understand the elements of recording a SMART objective two examples of setting a goal around weight loss have been provided below. The first does not meet the SMART criteria, whilst the second does.

1. Lose some weight before the summer
2. Decrease total body weight by 8kg, with at least 75% from body fat stores as measured by skinfold callipers, to be achieved in exactly 4 months from today

SMART objectives are often not written well because of lack of knowledge, but also because of fear of failing to achieve such a specific and time framed goal. It is easier to set a loose goal like the one in the first example because it is easy to achieve and justify that the result whatever it was, was at least heading the right direction.

Goals should stretch an individual to achieve, but be within their grasp and capabilities. Goals set beyond reach can serve to de-motivate once it becomes apparent that they cannot be achieved. It is important that the trainer understand that it is not their job to impose goals upon the client. This often happens because the trainer believes that because they are the expert they best know what needs to be done to help the client move forward. Whilst the PT is indeed an expert, setting goals for a client will not assist them in believing that they can reac h the targets set for them or help them in developing ownership of the objectives. A skilled trainer will work with a client and facilitate the creation of objectives that have been drawn from thoughts and ideas from both parties.

Devise an action plan

The aim of the consultation is to come to a workable solution and strategy for the client that leads them a step at a time towards the SMART goals that they are focused on. Once the questioning is complete and the PT has elicited all the information they require, they should begin to formulate an action plan which includes the following information:

1. Define point A – a summary of their current health and fitness as it is now
2. Define point B – identifying the various aims of the client through SMART goals across various stages of time including short, medium and long term
3. Determine key landmarks – identifying the necessary changes that need to be made along the way to most effectively reach each objective

4. Identify possible routes – identify multiple options and possibilities that will lead the client towards each objective in order to have several possible routes to success
5. Decide the preferred route – agree with the client which options or possibilities would be most suitable for their life and circumstances
6. Plan the journey – mapping out a step-by-step strategy showing how the preferred options will be implemented over time until the short, medium and long term objectives are achieved
7. Trainer/client contract – make an agreement on what the client promises to do and what the PT will promise to do to reach the agreed destination and goals

Example action plan

1. Define point A:

Carl is currently a full-time student with lectures from 9.00am to 5.00pm each day. He believes he drinks too much (around 35 units a week), although he does not smoke.

Carl has what he describes as a 'purely social' lifestyle. Although, he currently plays football, he does not especially train for it and will often be out socialising the night before. He does not have a weight issue and believes that his diet is relatively healthy. He attempts to eat as much fresh food as possible and minimises takeaway foods. One of his main issues is his lack of regular breakfasts.

From a current activity viewpoint, in addition to his weekly football, Carl cycles to college each day and does occasional training with the football team. This consists of running or circuit training. He is not on any medication and has no current injuries.

2. Define point B:

1st SMART goal (short) – to identify 5 healthy breakfast options and ensure that one of these breakfast options is eaten on at least 5 mornings of the week. This is to be implemented within the next 2 weeks.

2nd SMART goal (medium) – to be able to regularly play a full 90 minute football game, each week, without loss of physical stamina or performance in the last 20 minutes of the game and to achieve this within the next 6-8weeks.

3rd SMART goal (long) – to have achieved better balance in life between study, football, nutrition and social life so that each is successful and does not distract from the other. This is to be achieved within 4 months and judged based on a lifestyle questionnaire that analyses each specific area at the beginning and at 4 months.

3. Determine key landmarks:

Carl was very specific in this area and stated the following needs:

- to cut down on alcohol consumption
- include a good breakfast into his daily routine
- a regularly scheduled training plan each week
- training directed towards improving fitness specific to football

4. Identify possible routes:

Trainer and client jointly discussed a range of options to address Carl's current situation and to move him towards his aims:

- conduct a comprehensive fitness assessment to be able to measure progress plan in 3 football specific training sessions – Monday, Tuesday and Thursday in readiness for games played on Saturdays
- training programme to include acceleration, anaerobic, and functional resistance
- after a nutritional consultation to determine 5 different breakfast options Carl is happy to rotate through from day to day
- plan around Carl's social life to reduce alcohol consumption

5. Decide the preffered route

This needs to be mutually agreed by both the personal trainer and the client in accordance with the client's individual circumstances.

6. Plan the journey:

This action plan contains some actions for both of us:

1. Conduct a full fitness assessment (trainer)
2. Design a weekly training schedule (trainer)
3. Design 3 daily training session plans (trainer)
4. Identify what foods Carl is willing to eat in the mornings (Carl)
5. Create 5 healthy breakfast options (trainer/Carl)
6. Enlist the help and support of 3 friends (Carl)
7. Only drink every other night out – drink soft drink between beers (Carl)

Carl wants to start his training programmes as soon as possible and is prepared for a plan that contains gym work and sessions involving activities he can do from home such as running and cycling.

7. Trainer/client contract:

We discussed our mutual expectations of each other and agreed the following:

- Carl expects the trainer to provide motivation, to share in a weekly session, to be available outside the main sessions and to show an interest in helping Carl to achieve results
- trainer expects Carl to be motivated, committed and persistent. He will be ready on time, stick to the allotted training sessions and be committed to achieving and processing his goals

Timeframes

It is important when setting goals that they cover different periods of time so that all effort and focus is not directed towards a single point. By structuring different goals to cover a variety of times across the short, medium and long term, it provides impetus across a broader range where efforts need to be focused gradually across different elements of the overall objective and as a result help to achieve things in a step like fashion.

Goals should cover a variety of areas and be holistic in nature. Areas that can be covered in a holistic goal setting model include:

- health and fitness
- physical performance and improvement
- psychological, beliefs and behavioural
- daily lifestyle factors
- social implications, peer groups and habits
- functional capacity throughout daily life

Involving others

It can be a significant help to involve family or peers as a support network to aid in goal achievement. Friends and family who are in contact with the client more often than the PT will be able to have a more regular influence on them. A significant other may agree to join in with the nutritional changes. A friend may agree to become a training partner and encourage them at the gym each session. This will all support and motivate a client in their journey towards success.

Designing aerobic training programmes

As described in previous chapters, stamina fitness can be variously called aerobic fitness, aerobic power or VO_2 max. It can be thought of as the ability to take in, transport and utilise oxygen. In physiological terms, this is measured as a relative value -ml O_2 / Kg / min - or an absolute value - L O_2 / min. Designing aerobic training programmes is dependent on the short and long-term manipulation of the main principles of training – specificity, overload, intensity, frequency and duration (ACSM, 1998).

A number of key training variables can be manipulated to stress the aerobic and anaerobic energy systems. It is the purpose of this chapter to provide the PT with the necessary information to enable them to prescribe effective aerobic training programmes for beginner, intermediate and advanced clients.

Benefits of aerobic training

It is stressed that prior to exercise programming, clients must be thoroughly screened to assess their current health and fitness status. At this point it is beneficial to review the benefits of aerobic training:

- increase in stroke volume
- decrease in resting heart rate
- decrease in resting blood pressure (both systolic and diastolic)
- increase in capillarisation
- increase in the size and number of mitochondria
- increase in number of red blood cells
- increase in aerobic enzyme activity
- decreased incidence of disease
    - ✓ mortality from all causes
    - ✓ coronary heart disease (CHD)
    - ✓ cancer
    - ✓ hypertension
    - ✓ non-insulin-dependant diabetes mellitus
    - ✓ osteoporosis
    - ✓ depression
- improved ability to recover during and after training
- decrease in percentage body fat
- increased burning of fat at higher exercise intensities
- ability to work aerobically at higher exercise intensities
- enhanced sense of well-being

Adapted from ACSM (2001)

These adaptations are beneficial for all individuals including unhealthy, beginner client right through to an elite endurance athlete.

Modes of cardiovascular training

There are many different ways to train to boost the aerobic energy systems of the body. Health and fitness clubs tend to emphasise fixed cardiovascular equipment of which there are many different types including:

- treadmills
- upright, recumbent and spinning bikes
- rowers
- steppers and versaclimbers
- elliptical trainers

Whilst these form the bulk of cardiovascular training within health clubs they are by no means the only way. Group exercise classes offer a multitude of ways to increase cardiovascular fitness with many types of classes:

- choreographed aerobics
- step classes
- spin classes
- Body Training Systems (BTS) classes
- boxercise classes
- circuit classes

Fitness clubs that have a swimming pool also offer another way of improving cardiovascular ability either through swimming lengths or through aqua aerobics classes. PTs who plan their programmes suitably can even bring a cardiovascular element to resistance training through the use of supersets, giant sets, peripheral heart action (PHA) training or explosive body weight work such as jumping.

Types of aerobic training

There are several types of training that are widely recognised to benefit the cardiovascular system. These different types can be applied to most of the modes of CV training that were identified above with the appropriate planning.

1. Long slow duration (LSD) training

LSD training is what is usually identified as aerobic training. It involves working for an extended period of time (usually 10+ minutes) at a fairly low intensity. The intensity of this type of training does not change throughout the session. Traditionally, LSD training has been used to develop an aerobic base for de-conditioned individuals as well as forming the majority of training for endurance-based sports such as the marathon.

2. Interval training

Interval training involves structured periods of work and recovery aimed at developing the aerobic and anaerobic energy systems. The benefits of this type of training are that as well as developing all of the physiological systems involved in LSD training, the body's lactic acid tolerance abilities are also enhanced. When exercising at a higher intensity (which is the case in most sports and activities) enough energy can no longer be provided from the aerobic energy system. Therefore, the lactic acid energy system must be used to provide the remainder of the energy. Interval training improves performance in two key areas:

- increased ability to tolerate high levels of lactic acid
- improved rate at which lactic acid is removed from the muscles

3. Fartlek training

Fartlek is a Swedish term meaning 'speed play' and that is precisely what is done in this type of training – play around with the speed of training! It is an unstructured form of interval training where work is performed continuously for a specific duration, but instead of working at a single intensity, as in LSD training, the intensity is varied in a fairly sporadic manner. This is an excellent way of performing interval training and can be a lot of fun; particularly if, for example, performed outside in a park. The session could consist mainly of jogging around the park but then some sprints could be thrown in, followed by some walks to recover.

Prescribing exercise intensity

Traditionally, aerobic exercise has been prescribed by working at intensities within a range of 60-90% of maximum heart rate. Whilst this is a fairly simple way of prescribing intensity it does present a number of problems:

- 60-90% MHR is a very large range – is it better to work at the top end or the bottom end of this range?

Example:
A 20 year old client has been told by their trainer to work in the range of 60-90% MHR for aerobic training. 60% MHR for this individual is 120bpm, where as 90% MHR is 180bpm. This is a very large range indeed. If the client was fairly well conditioned, working at 60% MHR = 120bpm would create virtually no overload and therefore, very limited adaptations, if any would occur. Conversely, if the client was fairly de-conditioned, working at 90% MHR = 180bpm would represent an intensity that would be too difficult to maintain for a period of time. This would be de-motivating for the client and would probably put the client off further sessions!

- using % MHR to prescribe exercise intensity is very limited

Using the equation of 220 – age does give us a rough estimation of MHR; however, individuals of the same age can exhibit MHR's that can differ by +/- 11 bpm above or below their age predicted MHR.

Both of these factors present the PT with the same problem – traditional methods of prescribing aerobic exercise are not specific to individual needs. There is, therefore, a need to find a way of effectively prescribing aerobic intensity that is both specific to individuals and to the activities that they participate in.

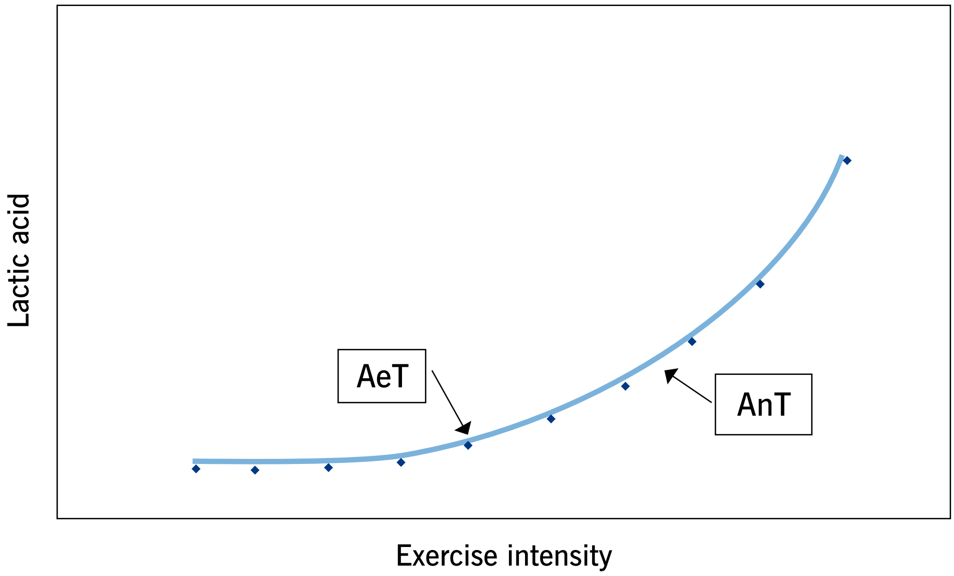
Metabolic thresholds

During low intensity activities virtually all of the ATP that is regenerated is done so via the aerobic metabolic pathways. As exercise intensity begins to increase a point is reached where the aerobic energy system can no longer continue to provide all of the energy. At this point, the body will have to start using the lactate anaerobic system to make up the shortfall. This point or threshold is the intensity at which the body will start to produce a small amount of lactic acid as the waste product of the anaerobic metabolism of glucose or glycogen. This is known as the aerobic threshold (AeT) and is defined as the exercise intensity where lactic acid levels first start to rise in the body.

The aerobic threshold (AeT) is identified by a sustained increase in blood lactate concentration above resting levels. This threshold marks the transition from aerobic metabolism to metabolism that is both aerobic and anaerobic. Exercise below the AeT is comfortable, sustainable and ideal for recovery or long-duration work. Exercise beyond the AeT is demanding but enhances performance by taxing aerobic respiratory mechanisms and improving one's ability to dispose of lactic acid.

As the intensity of exercise continues to increase beyond the AeT the body starts to rely more and more on the anaerobic energy system and lactic acid production increases accordingly. This continues to a second point or threshold known as the anaerobic threshold (AnT). This point represents the highest sustainable aerobic intensity before lactic acid levels start to rise uncontrollably. The aerobic threshold and anaerobic threshold can be illustrated graphically as follows.

Lactic acid production in response to increasing exercise intensity



Using objective (heart rate and VO_2 max) and subjective (RPE and breathing rate) data collected during the incremental fitness tests, it should now be easy to establish the AeT and AnT respectively. It is worth noting at this point that the lactic acid transition thresholds will be very specific to the exercise modality with which the test was conducted. For example, if the trainer measured the AeT and AnT on the rower, this would not carry over perfectly when prescribing intensity for running.

Identifying training zones

As these thresholds will occur at different intensities and different heart rates for each individual, the trainer now has all of the necessary information needed to start prescribing a personal aerobic training programme. Based on the above information and for simplicity four specific zones are proposed. Using the table below it should be easy to prescribe specific zones of intensity for the client.

Zone	Upper limit	Physiological correlates			
		Blood lactate	%MHR	%HRR	RPE
1	recovery	resting level	50-60	40-50	$\leq$10
2	aerobic threshold (AeT)	manageable increase above resting level	60-75	50-65	11–12
3	anaerobic threshold (AnT)	significant and rapid rise	75-90	65-85	13–15
4	anaerobic 1	>4 mmol/l	80-95	80-95	16–17
4	anaerobic 2		95-100	95-100	19

Zone 1 - recovery

Recovery zone training comprises all intensities below the AeT. This type of training will produce limited adaptations to the aerobic systems due to the low intensity and associated lack of overload; however, this type of training is useful for the following purposes.

- appropriate intensity for severely de-conditioned clients or those in special population groups
- appropriate intensity for warm ups and cool downs
- training in this zone can be used during 'recovery' sessions – typically performed the day after a very heavy session (both aerobic and resistance). This will promote recovery by increasing the blood flow to the working muscles. Recovery sessions would seldom be more than 30 minutes in duration
- can be performed during certain phases of training when aerobic fitness is not a high priority – for example hypertrophy phases
- most commonly used as the recovery intensity during interval training sessions. The exact intensity of recovery will depend on the intensity and duration of the work period of interval session

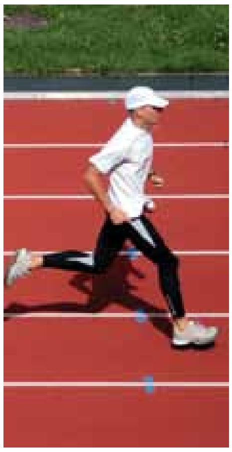
Zone 2 - aerobic threshold (AeT)

AeT training is performed at intensities between the aerobic and anaerobic thresholds. These intensities are usually performed as long, slow duration (LSD) training sessions. AeT training is the minimum intensity that is recommended to improve aerobic fitness and reduce disease (ACSM 2000). The following adaptations can be expected:

- increase in capillary density
- increase in myoglobin
- increase in the number and size of mitochondria
- increased energy stores (ATP, glycogen and FFA's)
- increased ability to oxidise fat and spare glycogen

However, exclusive use of this type of training will probably not provide huge increases in aerobic sports performance. AeT training can be performed for any length of time between 10 minutes to several hours. The duration of training within this zone will depend on the client's fitness levels and training goals. The specific intensity will depend on the duration of training – the longer the session the lower the intensity within the aerobic zone.

Zone 3 - anaerobic threshold (AnT)

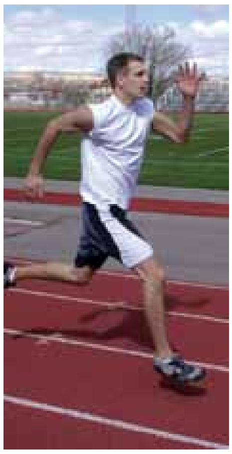


AnT training is a very specific type of training performed at exactly, or as close as possible, to the anaerobic threshold. This type of training will maximise the aerobic benefits previously discussed as well as develop the client's lactic acid tolerance and improve their ability to remove the waste products of anaerobic metabolism from the muscles. Training at AnT is demanding and should only be undertaken by clients who have an appropriate level of physical conditioning.

Typically, AnT sessions last between 20 – 40 minutes with the recommendation to use a heart rate monitor to aid control of intensity. Ideally HR should not deviate much more that 2-3 bpm either side of the AnT heart rate. In conjunction with heart rate, RPE should be encouraged with the perceived intensity rate of 'hard' or RPE 13-15.

The main training response of this type of session is to cause a shift to the right of the lactic acid curve detailed previously. As a result the AeT and AnT will now occur at higher exercise intensities, indicating increased aerobic performance. For this reason, AnT is the best performance predictor in endurance athletes.

Zone 4 – anaerobic



Any intensity above the AnT is termed the anaerobic zone. Exercise at these intensities can not be maintained for long periods due to very rapid increases in lactic acid. For this reason, interval training is the preferred method and is widely used. Using intervals has a number of benefits, these include:

- time efficient
- increase in anaerobic enzymes
- increased ability to buffer lactic acid
- increase in VO_2max
- burn more calories

Anaerobic zone training will improve the body's ability to transport the waste products of anaerobic metabolism away from the working muscles. This is vitally important for activities that are intermittent in nature. In addition, endurance athletes who need to work anaerobically at times during a race or training session will benefit too.

The specific intensity during interval training is completely dependent on the training goal of the client. For example, a 10,000m runner would benefit from longer intervals and shorter recoveries. The intensity of the work period would be only slightly above the AnT. Conversely in an intermittent sport, such as tennis, the work period of the interval would be of a higher intensity but of a lower duration. This notion introduces the idea of analysing an activity for the energy systems used and prescribing exercise that is specific to the demands of that activity. The following table provides some guidelines for suggested work to rest ratios when performing interval training sessions.

Training emphasis (energy system)	Work : rest ratio
Aerobic	1 : _ - 1:1
Lactate	1 : 2 – 1 : 4
Phosphate	1 : 6

The information contained within this table is only a guide. Performing interval training with varying work to rest ratios is beneficial for all levels of client and client ability (beginner to elite) as it varies the training stimulus.

Programme design considerations

Beginners

Beginners should undertake moderate intensity activities that are associated with minimal muscle soreness, discomfort and injury. It is recommended that beginners train 3 to 4 times per week and that the duration of sessions begins at 15 to 20 minutes and increases to 30 minutes (ACSM, 2000). Adherence will be optimised if the training programme is not initiated too aggressively. Beware, however, that the improvement in aerobic fitness of beginners is rapid and may plateau in as little as three weeks unless the training stimulus is increased (Hickson et al, 1981). For these reasons, the fitness professional should set realistic goals early in the exercise programme. The following ACSM guidelines are a useful starting point when designing aerobic fitness programmes for beginners.

Variable	Recommendation
Frequency	3 to 5 days per week
Intensity	55/65% to 90% of maximum heart rate (HRmax)
	40/50% to 85% of HRmax reserve (HRR)
Duration	20 to 60 minutes
	At least 20 minutes for vigorous activities
	At least 30 minutes for lower-intensity activities
Mode	Any activity that uses large muscle groups in a rhythmic nature, such as walking, jogging, running, cycling, cross-country skiing, aerobic dance, group exercise, rope skipping, rowing, stair climbing, swimming, skating, and various endurance games and sports

Intermediate exercisers

The goal of this stage of training is to gradually increase the exercise stimulus in order to significantly improve cardiorespiratory fitness (ACSM, 1998). Intermediate exercisers can be progressed more rapidly than the beginner. Exercise intensity increases towards 80-85% of HRR and duration increases every 2 to 3 weeks until participants are able to exercise continually at a moderate to vigorous intensity for 20 to 30 minutes. It should be stressed that deconditioned and / or older individuals may take longer to adapt to a training programme.

Advanced exercisers

After 5 or 6 months, clients may or may no longer be interested in increasing the training stimulus, and the goal of training may become the long-term maintenance of cardiorespiratory fitness (ACSM, 1998). If this is the case, aerobic fitness can be maintained by training 3 times per week for 20 minutes (Hickson et al, 1982). However, cardiorespiratory fitness will be lost if exercise intensity is decreased (Hickson et al, 1985).

Aerobic programme design examples

The following two examples demonstrate how the PT could put together a week of aerobic training for their clients.

Example 1	
• 25 year old female • advanced level of fitness – good distance runner • wants to improve her 10,000m time • AeT and AnT worked out on an incremental treadmill test • AeT = 12 km/h – 150 bpm RPE 12 • AnT = 14 km/h – 165 bpm RPE 15-16	
Monday	Zone 1 - recovery run outside – duration = 25 mins – intensity <145 bpm (RPE 10)
Tuesday	rest day
Wednesday	Zone 4 – anaerobic 1 • interval session on treadmill – duration 35 mins • warm up 5 mins at 10 km/h • 3 minutes at 16 km/h followed by 2 minute recovery at 10 km/h x 5 (RPE 16-17) • cool down at 10 km/h down to walking
Thursday	rest day
Friday	Zone 3 – AnT • run outside – duration 20 minutes • intensity 162 -168 bpm (RPE = 14-15)
Saturday	rest day
Sunday	Zone 2 – AeT • run outside – duration 45 minutes • intensity 150 – 160bpm (RPE 11-12)

Example 2	
• 40 year old male • fairly new to training • overweight – wants to exercise to help with fat loss • enjoys cycling • AeT – 140 bpm • AnT – 155 bpm • AeT and AnT established on cycle in gym	
Monday	rest day
Tuesday	Zone 2 – AET • cycle outside – duration 45 minutes – intensity between 140 – 150 bpm (RPE 11-12)
Wednesday	rest day
Thursday	Zone 3 - AnT • interval session on cycle in gym – duration 30 minutes • warm up 5 minutes at around 130 bpm • 2 minutes at AnT = 155 bpm followed by 2 minutes at 130 bpm x 4 (RPE 13-15) • cool down 5 minutes at 130 bpm decreasing down
Friday	rest day
Saturday	Zone 2 – AeT • cycle outside – duration 1 hour – intensity between 140 – 150 bpm (RPE 11-12)
Sunday	rest day

These two examples, demonstrate how AeT and AnTs allow the trainer to prescribe individual aerobic programmes. Fundamentally, in each of the above examples it is the training principles that have been adapted– intensity, duration and frequency. For example, client number 2 is unable (deconditioned) to complete 4 aerobic sessions per week and would also find a threshold session too difficult at this stage.

The two examples above do not include any resistance training that a client may or may not be performing.

It is also important to point out that the above examples should be considered as such. Could they have been put together in a different format for both clients? Yes, however as long as AeT and AnT data is combined with the sensible application of training principles any number of workout combinations can be performed.

Student Task

Using the data from your own aerobic and anaerobic threshold tests, write yourself an interval training session that you can perform in the gym during the following practical implementation session. The session should last for approximately 45 minutes and should include a specific warm up, main interval session and cool down. Think about the work to rest ratio of your intervals – do they match the demands of your chosen activity?

Planning long-term aerobic training programmes - phases of training

Variety is a key component in designing training programmes. Long-term success depends on successful manipulation of training variables over a period of time. Periodisation is the term given to the manipulation of training variables over time and is typically divided into phases (Hawley and Burke, 1998). Dividing training into phases has a number of benefits:

- helps prevent burn-out
- more enjoyable
- focuses on goal
- reach goals in shorter time period

Specific phases include:

- foundation or base training
- transition or threshold phase
- speed or power phase

1. Foundation or base training

This phase is used to establish what is called an aerobic base and to enhance those adaptations associated with improving VO_2 max. Foundation training is most often characterised by what is known as LSD. (Long Slow Distance) training and can be quantified by working at AeT (zone 2) and AnT (zone 3) or RPE 11-15 for at least 30 minutes. Alternative activities, which could be performed alongside this, could include postural correction and conditioning, and muscular endurance-based resistance training.

2. Transition or threshold training

The next phase of training is sometimes called the threshold stage (Hawley and Burke, 1998) or 'early quality work' (Daniels, 2001). This is undertaken in the belief that it will increase the athlete's ability to accommodate the changes in blood chemistry associated with higher intensity work, which can ultimately lead to fatigue. Typically this phase consists of interval training type work (zone 3 and 4) where the client would perform work repetitions of five to ten minutes duration at an intensity equivalent to 85%- 95% vVO2 max or 85%-95% HR max (RPE 16-17).

3. Speed or power phase

Speed and power training enables the client to 'learn' how it feels to work harder than normal, and should have a biochemical and neuromuscular effect in terms of 'teaching' the relevant muscles to cope with faster velocities. Intervals are typically used in this phase where the client performs work up to three minutes in duration at an intensity equivalent to 95-100% MHR RPE 19.

In addition, athletes will go through an additional phase which may be called the 'taper' or final quality phase of training. This is concerned with work that is of high quality but which leaves the client in a relatively fresh state so that they can perform at their target event as well as they are able to. In terms of athletic training, this is quite a controversial area with many different theories and ideas passed around. Again, it is worth pointing out that clients are, by and large, not full-time athletes and have other demands on their time. As a consequence, the basic guideline that can be given here is keep the quality of the work high, the duration and frequency low and make sure they rest well and eat properly.

Final note: it must be stressed that training intensity is gradually increased throughout each phase. No phase consists solely of one method or training zone (intensity); rather, training will consist of a combination of different zones and methods, which will change throughout the year. Furthermore, to prevent overtraining and optimum benefit, PT's must ensure adequate rest and recover between workouts and training phases (see 'periodisation' chapter).

Student Task

Design a 12-week aerobic training programme for an intermediate male exerciser who wishes to compete and achieve a personal best time in a local 10km race. At present he feels his training is stagnating and has asked you for help; as he is due to compete in twelve weeks time. He currently runs for 60-minutes on Monday, Tuesday and Thursday, with a 90-minute session on a Saturday. He is available to train on all days of the week and is prepared to follow your advice to the letter to achieve the above.

Using the major training variables demonstrate progression over 12-weeks.

12 Week Plan

Week	Mon	Tues	Wed	Thu	Fri	Sat	Sun
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							

Designing endurance and hypertrophy based resistance training programmes

Once the relevant information has been collected and goals have been discussed a trainer must prescribe the most appropriate exercise to achieve the desired goals. Planning a resistance session will be an essential part of achieving many objectives surrounding health and fitness. A good PT will have worked with the client to produce short, medium and long term objectives as part of a consultation and appraisal process. A resistance training programme should reflect these different objectives and should also have short, medium and long term stages of design consistent with established practises around periodisation.

The frequency of sessions and physical demands of training should be consistent with the goals set and should also be agreeable to the client. Pushing a client too hard or making training too easy will only serve to damage adherence patterns and as a result goal achievement.

Programming for different objectives

The table below provides the various programme objective guidelines. Once the objectives of the client have been ascertained the appropriate intensities, set and rep schemes, recoveries and frequencies can be selected.

Training goal	Strength	Hypertrophy	Endurance	Health	Cardiovascular
Intensity	High	Moderate	Low	Low (aerobic)	60-90% MHR
Load as % of 1 RM	>85%	67-85%	<67%	N/A	N/A
Reps / duration	1-5	6-12	12+	30 mins +	20 mins +
Recovery between sets	3-5 mins	1-2 mins	30-60 seconds	N/A	N/A
Sets per exercise	2-6	3-6	2-3	1	1
Frequency per muscle group	1-2 x per week	1-2 x per week	2-3 x per week	5 + sessions weekly	3 + sessions weekly

Adapted from Baechle & Earle (2000)

When selecting a weekly workout frequency, the trainer should consider the training age of the client, the availability of the client and the set objectives. The following table (Baechle and Earle, 2000) provides a simple illustration of how the trainer can manipulate the variable of frequency as the client's training age / experience increases. It begins with a requirement of only 2 sessions per week, which represents the national average attendance.

Training status	Frequency guidelines (sessions / week)
Beginner	2-3
Intermediate	3-4
Advanced	4-6

Total sessions per week for different training ages

It should be noted that these frequencies are based on resistance training sessions per week (not aerobic, flexibility sessions etc), and that these are guidelines only. Exceeding the maximum recommended frequency on a regular basis would be inadvisable however, as the client's ability to recover from the load would be compromised.

Programme rules and workout construction

Basic programme design rules as identified at level 2 include:

- promote muscular balance
- train large muscles earlier in the programme
- complex and high skill exercises earlier in the programme
- synergists and fixators later

Resistance training for beginners

Beginner clients require a logical and structured introduction into the world of resistance training. This will allow them to 'walk before they can run', and develop a solid foundation that can be built upon as they progress. The deconditioned beginner will often present with the following general issues:

- poor technique
- poor proprioception
- lack of muscular strength and endurance
- poor aerobic conditioning
- low tissue tolerance
- weak connective tissue
- poor posture
- poor core strength

The PT should appreciate these issues and programme accordingly so the client can make improvements and safely progress towards their objectives.

Programme aims for beginners

A resistance-based programme designed for a deconditioned novice client should meet certain criteria. On a basic level the trainer should ensure that the programme adheres to the programme design rules. The programme should also meet and achieve the following objectives:

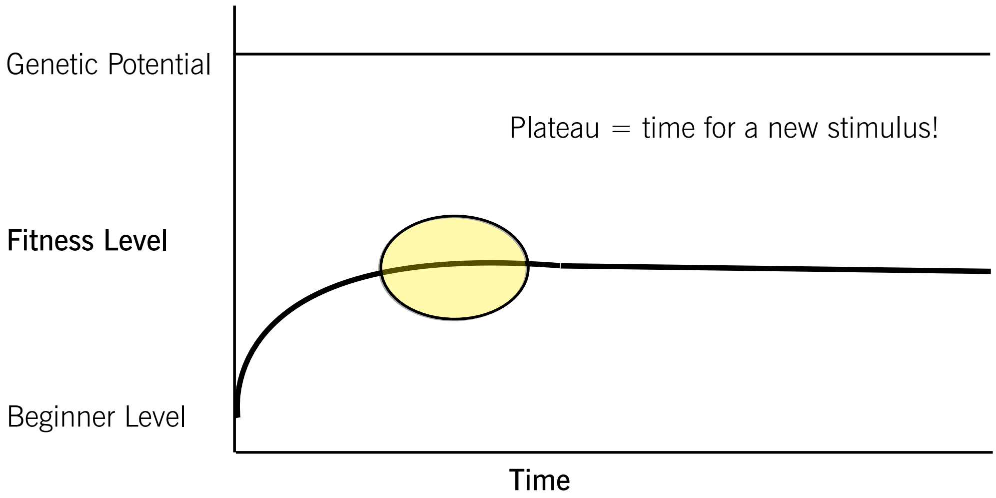
- improve proprioception
- improve posture
- increase tissue tolerance for exercise
- improve core strength
- enhance function
- provide variety
- provide a sense of achievement

The need for progression

Each individual has a genetic potential that defines how far their fitness could progress if training, nutrition and recovery were optimised. The deconditioned novice has a large adaptation potential because they are starting from a point far below their genetic limits. Consequently, Fleck and Kraemer (1997) contend that almost any programme will work for an untrained individual, as they have a great adaptation potential and are unfamiliar with any exercise stimulus. It is as a result of this adaptation potential that novice clients tend to make rapid progress initially once exposed to the exercise stimulus.

The initial rate of gain often experienced by the novice client usually begins to slow down within a few weeks. It is important that the PT appreciates that a new stimulus needs to be introduced at this point, and structures an appropriate adjustment or alteration to the fitness programme to keep progress moving in a positive direction. This is discussed in more depth in the chapter on periodisation.

Once the client's physiology has adapted to the workout stimulus, the onus is on the PT to make appropriate programme modifications. If appropriate modifications are not made the client's progress is likely to plateau. In the medium to long term, stagnation is likely to cause dissatisfaction and lead to problems with exercise adherence and client retention. Programme modifications should be designed to build on the foundation of the previous training phase, thus enabling the client to make further progress.



Programme variables

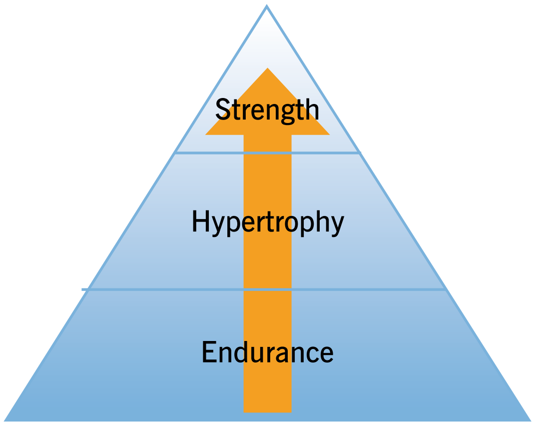
When the time comes to change a resistance training programme, the PT can manipulate a wide variety of variables. These include:

- number of exercises
- number of sets
- target repetition range
- recovery periods between sets
- workout frequency
- movement speed – slow to fast
- different exercises
- stable to unstable
- simple to complex
- split routines

Basic resistance progression

In order to physically progress a client over a prolonged period of time it is important that the trainer develops a long term training plan. Adopting a logical approach to planning promotes a structured and progressive approach to exercise that can facilitate long term development, promote variety, structure adequate rest periods and minimise the likelihood of overtraining. Long term planning also allows the client to see how they are going to progress from their current fitness levels towards their overall objective.

When planning to take a client from novice level through to the more advanced and intensive forms of resistance training, the following basic progression pyramid should be adhered to.



Basic progression pyramid

A thorough examination of the client's previous exercise experience, training routines and adherence patterns will provide an indication of their suitability to perform certain types of resistance training. The novice client should be allowed time to develop sufficient connective tissue strength, anaerobic conditioning and tissue tolerance to be able to safely perform the training load required to achieve higher intensity objectives.

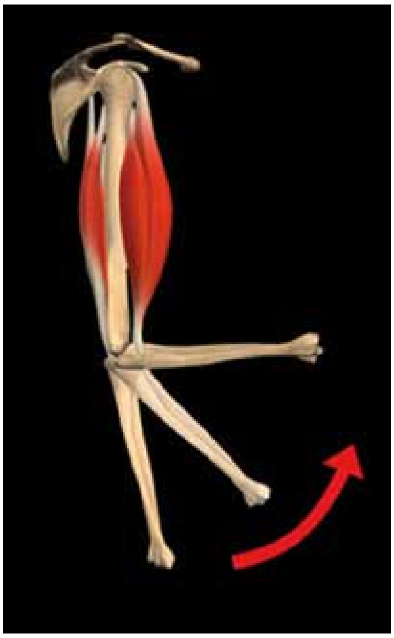
The basic pyramid approach to resistance training progression over time will only apply if the client's goals include training towards strength and or hypertrophy. Many clients will not want to focus on these aspects of muscular fitness, in which case the pyramid approach may not be applicable. If this is the case, then the trainer has various options. Firstly, there is scope for intensity progression within each training objective. For example, if a client wants to focus predominantly on muscular endurance, the guideline of 12+ repetitions per set can be subdivided into smaller repetition ranges. Successive training phases might progress from 18-20, 15-18, 12-15 reps per set. This would provide small increments in intensity while still remaining within the muscular endurance repetition range. A second option would be to keep the repetition range the same, but amend other programme variables (see previous list). Increasing the movement complexity from phase to phase while working with the same endurance repetition range is one of many possible options.

Hypertrophy

Many clients will ultimately wish to progress to a programme where aesthetics are the main goal and begin to gravitate towards training for hypertrophy. This type of training should only be embarked upon once a solid foundation of technique, posture, basic cardiovascular fitness and flexibility has been built.

Hypertrophy physiology

As with many of the physiological functions of the body, the precise mechanism by which muscles increase in size is not yet completely understood. There are many competing theories attempting to explain the adaptations that take place at a cellular level, but no one theory has been universally accepted as yet.



Robergs & Roberts (1997) define hypertrophy as the increase in size of skeletal muscle resulting from the increased size of individual muscle fibres. McArdle et al (2001) suggest that the primary driving force that initiates skeletal muscle hypertrophy is increased muscular tension, typically generated through resistance exercise. It has been reported that the fast-twitch fibres of weight lifters are on average 45% larger than those of sedentary individuals and aerobic athletes (McArdle et al, 2001).

Training to significantly increase muscular size is not particularly easy. Convincing the human body to synthesise and sustain higher levels of muscle mass than it would ordinarily support requires planning, application and sustained effort. Individuals wanting to increase in size need to carefully consider the training stimulus, ensure appropriate nutrition and plan adequate recovery. There are three key variables that need to be considered.

Factors affecting hypertrophy		
Training	→	Hypertrophy!
Nutrition	→	
Recovery	→	

The 3 principal modifiable contributing factors to hypertrophy

Hypertrophy training should not just be considered the domain of bodybuilders and young males wanting to ‘get big.’ Phases of hypertrophy training can be utilised by all individuals that participate in a wide variety of sports and athletic events. Newton and Kraemer (1994) contend that hypertrophy training can prove highly beneficial to power athletes, provided that they also include dedicated power exercises and do not exceed the ideal optimal muscle mass for their sport or event (especially if power to weight ratio is a key consideration).

Hormonal responses

Hormones can by divided into two general categories:

- anabolic
- catabolic

Anabolic hormones promote the building of structures within the body. With the aim of a hypertrophy training phase being the building of skeletal muscle, it would be prudent to maximise the effects of the anabolic hormones. The characteristic male sex hormone testosterone is known for its anabolic properties. Testosterone plays an important role in muscle growth due to its role in protein synthesis. Males exhibit approximately ten times greater testosterone concentrations than females (Hedrick, 1995). This is one reason why males are able to achieve significantly greater levels of hypertrophy than females. Hedrick (1995) suggests that exercise guidelines for maximising an anabolic response are as follows:

- select exercises that involve a large amount of muscle mass (e.g. squats, deadlifts)
- utilise a relatively heavy resistance (~85% 1RM)
- use a moderate to high volume of training (multiple sets)
- emphasise short rest periods between sets (~1 minute)

Catabolic hormones break structures down within the body. Chronically high levels of catabolic hormones within the body would be counterproductive to the objective of hypertrophy. Cortisol is one of the most catabolic hormones found within the human body. One of the major roles of cortisol involves the conversion of stored protein (muscle) into glucose and glycogen. As well as catabolising existing protein, cortisol decreases protein synthesis, thereby inhibiting muscular gain (Jalali, 2003).

Jalali (2003) suggests the following tips for controlling cortisol levels:

- ensure that an adequate quantity and variety of nutrients is consumed on a regular basis
- avoid overtraining. Do not train 3 or more days in a row without a break, and keep workout duration under one hour
- avoid stress. Practice relaxation techniques
- try to sleep at least 8 hours each night
- spike insulin levels after a workout. Insulin levels may enhance post-workout cortisol clearance, promoting the switch to anabolism. Consumption of a high glycaemic index carbohydrate drink or snack will generate an insulin spike

Changing the stimulus

Approximately every 4-8 weeks the PT should look to modify the programme variables in such a way as to generate a new exercise stimulus for the client. If planned correctly, this practice should help ensure physical progress as well as minimising the risk of retention problems through boredom. Care should be taken to ensure that the progressions in volume and intensity from one programme to the next are both progressive and manageable e.g. conducting a strength endurance phase in between endurance and hypertrophy phases. These progressions in programme design can be timed with pertinent re-evaluation and review dates.

Hypertrophy guidelines

When training for hypertrophy the number of sets performed per muscle group is far greater than for muscular endurance. Baechle et al (2000) suggest that multiple exercises (i.e. 3 or more per muscle group) is the most effective strategy for increasing hypertrophy. The training intensity (expressed as % of 1RM) is also significantly higher for hypertrophy than it is for muscular endurance. It can therefore, be stated that a key feature of hypertrophy training is high volume combined with moderate to high exercise intensities.

Characteristic	Endurance	Hypertrophy
Intensity	Low	Moderate
Load as % of 1RM	<67%	67-85%
Suggested rep range	12+	6-12
Rest between sets	30-60 seconds	1-2 mins
Sets per exercise	2-3	3-6
Frequency per muscle	2-3 x per week	1-2 x per week
Workout type	Whole body	Split routine

Comparison between endurance and hypertrophy guidelines

Split routines

Inevitably, when progressing from the initial use of whole body routines towards hypertrophy there will come a time when the trainer cannot fit the volume of work required into the time available. The vast majority of clients do not have the time, or the physical resilience to train for hours on end, and so a different approach to resistance training needs to be employed.

Split routines involve moving away from the whole body approach by splitting the body up in to two or more groups of muscles. These groups of muscles can then be trained on separate days in a cyclical fashion. The following are examples of popular hypertrophy training splits:

Option A – the 2-way split						
Mon	**Tue**	**Wed**	**Thur**	**Fri**	**Sat**	**Sun**
Lower body		Upper body		Lower body		

Option A (above) splits the body into two distinct areas: upper body and lower body. These areas are worked separately over two alternating workouts. The sequence depicted above would be reversed during the second week of the training phase, so that each workout is repeated three times every two weeks.

Option B – the 2-way split (increased frequency)						
Mon	**Tue**	**Wed**	**Thur**	**Fri**	**Sat**	**Sun**
Lower body	Upper body		Lower body	Upper body		

Option B takes the 2-way split concept from option A and progresses it by increasing the frequency of the workouts from three times every two weeks to twice per week.

Option C (a) – the 3-way split						
Mon	Tue	Wed	Thur	Fri	Sat	Sun
Back & biceps		Legs & deltoids		Chest & triceps		

Option C (b) – the 3-way split						
Mon	Tue	Wed	Thur	Fri	Sat	Sun
Chest & biceps		Legs & deltoids		Back & triceps		

C (a) + C (b) above are two examples of 3-way splits. The splitting of the major muscle groups (the musculature of the chest, back and legs) is identical for both examples. This split is a very popular way to divide the key areas of the body. The way in which the smaller muscle groups are divided is very much a case of personal preference.

In option C(a) the smaller muscle groups of the upper arms are worked on the same day as the major muscles they act synergistically with. For example, the triceps brachii are involved in all pressing movements. As many of the popular pectoralis major exercises involve pressing actions (e.g. bench press), the triceps brachii would receive stimulation from the chest workout. Training the triceps after the chest would rapidly fatigue the triceps muscles that have already been involved synergistically in the workout.

In option C(b) the upper arm muscles have been deliberately placed with major upper body muscle groups that they do not tend to work synergistically with. The rationale for this approach is twofold. Firstly, the upper arm muscles essentially get trained twice a week by using this approach: once directly and once indirectly while acting as a synergist for a larger upper body muscle group trained on a separate day. Secondly, many individuals perceive that they can train the upper arm musculature more effectively if it has not been pre-fatigued through synergistic involvement in other exercises.

Planning criteria for split routines:

- the planned schedule meets the requirements of the client in terms of time available
- the frequency at which workouts are repeated does not exceed the maximum recommended for each training goal
- the workout planned for any given day is not adversely affected by the previous day's session
- adequate recovery is planned into the weekly cycle (usually at least 2 days off for each body part or muscle group)

Disadvantages of split routines:

Changing to a split routine also has some potential disadvantages that the trainer and client should be aware of:

- a greater workout frequency is required
- increased workout frequency may lead to overtraining
- missing one workout will potentially unbalance the whole training week
- split routines require intelligent planning and forethought

Exercise selection

When choosing exercises to train for hypertrophy, it is important to remember that stimulating and fatiguing as many fibres as possible is the primary objective.

When selecting exercises to include in hypertrophy workouts the trainer should include a variety of the following:

- free weight compound exercises
- free weight isolation exercises
- machine and cable-based exercises

When selecting fixed path resistance machines to incorporate into the hypertrophy programme, the trainer should apply common sense and have a critical eye. One of the major criticisms of fixed path machines is that they are not always adjustable enough to suit all body types, shapes and sizes. As a result of this, a machine that works well for one individual may be considered inappropriate for another.

Putting the workouts together

A simple step-by-step formula can be followed in order to produce safe and effective resistance training sessions. This formula is depicted below:

- identify the training objective (e.g. hypertrophy)
- design a weekly split based on the objective and time available to the client (which muscles are grouped together on which days?)
- pick set and rep schemes appropriate to the client's current physical ability
- select exercises for each muscle (exercises should suit the objective)
- order the exercises to be performed on each day following the basic programme design rules

Check that the volume of work will fit into the time available for each session.

Student Task

Design a training programme for a 26 year old male client that has the long-term objective of hypertrophy. The programme should include a weekly split pattern (either two or three way), with each workout within the split detailed in the tables below.

___________ way split							
Week	Mon	Tue	Wed	Thur	Fri	Sat	Sun
1							
2							

Exercise	Sets x reps	Recovery
	X	
	X	
	X	
	X	
	X	
	X	
	X	
	X	
	X	

Exercise	Sets x reps	Recovery
	X	
	X	
	X	
	X	
	X	
	X	
	X	
	X	
	X	

Exercise	Sets x reps	Recovery
	X	
	X	
	X	
	X	
	X	
	X	
	X	
	X	
	X	

Training systems

Training systems add variety to resistance training. A number of training systems have been developed. Appropriate inclusion of these training systems can enhance a workout by providing a new physical stimulus for the body to adapt to, as well as providing variety from a psychological point of view. Remember that no one training routine or training system is perfect. Each can be used for a phase of training, but it must be remembered that the body will adapt to the stimulus relatively quickly. Cycling the training systems as well as the exercises, volume and intensity of the workouts will ensure mental and physical stimulation for clients. The following section will outline a number of popular training systems and discuss when they are best used. Training systems should be thought of as "plateau busters" or ways of increasing the intensity of a workout dramatically. They should only be utilised within a structured periodised plan as over use of such systems can rapidly result in over training and regression.

1. Multiple-set system, or 'setting'

The multiple-set system, or 'setting' probably forms the basis of the majority of resistance-based workouts performed in gymnasiums today. This system consists of an appropriate warm up followed by multiple sets of the same repetitions performed with a given weight. For example, 3 sets of 10 repetitions (3 x 10), or 5 sets of 5 repetitions (5 x 5).

The intensity and volume of multiple set workouts can easily be manipulated by varying the load (% of 1RM) and the number of sets performed per exercise. In this way, the multiple set system can be seen as highly versatile, as it can be used to work towards any of the fundamental resistance based training objectives (i.e. endurance, hypertrophy, strength). Examples of how progression can occur in successive workouts using the multiple-set system are listed below.

Progressive resistance Objective – strength: session target - 5 x 5		
Workout	Reps achieved	Load (kg)
1	5,5,4,4,3	100
2	5,5,5,4,4	100
3	***5,5,5,5,5***	**100**
4	5,5,4,3,3	102.5
5	5,5,4,4,4	102.5

Example 1 - multiple sets using progressive resistance

Progressive repetitions Objective – hypertrophy: session target - 4 x 6-8		
Workout	Reps achieved	Load (kg)
1	7,7,6,6	100
2	8,7,7,6	100
3	8,8,8,6	100
4	***8,8,8,8***	**100**
5	7,7,6,6	102.5

Example 2 - multiple sets using progressive repetitions

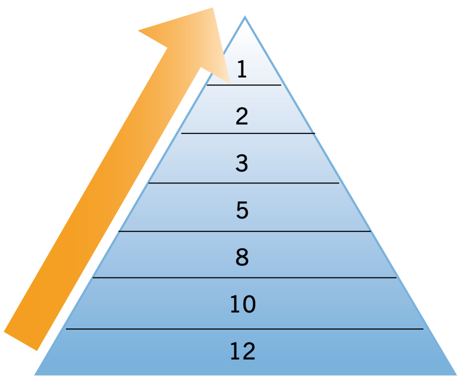
The examples above show how a client could progress using the multiple-set system over a number of workouts. The progressions are controlled in a very similar way in both examples. In the first example, the trainer will impose a sets x reps target for the client and the resistance will only be increased when all repetition targets are met. In this example, the client achieves the 5 x 5 target during workout 3, and so the load (resistance) is increased slightly for workout 4.

The second example works in much the same way. In this example, the trainer will only increase the load once the client can complete all sets at the upper end of the target repetition bracket (i.e. completes 8 reps within the 6-8 rep range). Note that the load progression in both examples is small. Small increments allow sustained progression over time, which is the cornerstone of any successful resistance training programme. Load increments of 5% or less should allow for sustained progression if applied at appropriate times.

2. Pyramid training

Pyramid training involves manipulating the load and repetitions over the course of multiple sets of the same exercise. The basic concept of a pyramid involves progressively increasing the load and decreasing the repetitions with each successive set. The trainer should ensure that the client is adequately rested prior to commencing the subsequent sets (rest periods can be timed in order to achieve consistency of effort from workout to workout).

Set	Reps	Load (as % of 1RM)
1	12	70
2	10	75
3	8	80
4	5	85
5	3	90
6	2	95
7	1	100



Reps and loads for the pyramid system training – from Poliquin (2001). Rep progression for an ascending pyramid

The pyramid system is widely known and is often utilised in resistance training programmes. Pyramiding can be performed in three distinct ways: ascending pyramids, descending pyramids, and complete pyramids.

Ascending pyramids adopt a light-to-heavy approach, whereby each successive set is performed with a heavier resistance for fewer repetitions. The descending pyramid starts with the fewest repetitions and the heaviest load (following an appropriate warm up) and for each subsequent set a percentage of the load is removed. The lighter load allows more repetitions to be performed than the previous set. The complete pyramid combines the ascending and descending approaches. Starting light the client builds to the peak over a number of sets, then attempts to repeat the same repetitions on the descending phase.

3. Drop sets (strip sets)

A drop set is a resistance training system that is popular among bodybuilders. It is a technique that allows a client to continue a set past the point where it would usually terminate. Drop sets, sometimes referred to as stripping, involves performing a set to failure, then removing a small percentage of the load and continuing with the set. This procedure can be repeated several times (2 to 3 drops in load per set is standard). A set to failure followed by three successive load decrements performed with no rest would be referred to as a triple drop. The key points for successfully performing drop sets are listed in the table below.

Guidelines for planning and performing drop sets
• select an initial repetition range within the guidelines of the phase of training planned • decide how many drops are going to be performed (a higher number of drops will increase sensations of fatigue and discomfort) • select which exercise(s) are going to be used in conjunction with the drop sets system. perform all planned sets of the exercise as normal when concentric failure is reached, lower the load by a small amount (5-20%) and continue the set immediately • repeat for as many drops as desired. Note that only a small number of repetitions should be completed with the new load once the weight has been lowered

Example: for a client training for hypertrophy the following drop set procedure could be employed:

Drop sets – DB shoulder press			
Set	Reps	Load (kg)	Recovery (sec)
1	10	25	60
2	10	25	60
3	10	25	60
4	10 (to failure)	25	None
Drop 1	4 (to failure)	22.5	None
Drop 2	3 (to failure)	20	None
Drop 3	2 (to failure)	17.5	N/a

It should be noted that as drop sets extend a set beyond the usual point of termination (i.e. concentric failure), it can be considered a demanding training technique. Many individuals overuse systems such as drop sets by including them in every set of every workout. This approach is likely to lead to rapid burnout and stagnation of results.

4. Supersets

The superset system involves performing two different exercises back-to-back with little or no rest in between (Siff, 2003; Fleck and Kraemer, 1997). There are three key variations of this system. The first variation of supersetting involves performing two exercises for the same muscle back-to-back. 12 squats followed immediately by 12 lunges would be one superset for the quadriceps and gluteals. This sequence can be repeated following a standard rest interval.

The second exercise in each superset is always performed with significant muscular fatigue present. As a result of this fatigue the intensity of the second exercise is always much lower than if the muscle had been allowed to recover during a standard rest interval. This renders this type of supersetting relatively ineffective for maximal force development (strength training). However, completing two exercises in this manner would be good for local muscular endurance and possibly hypertrophy because the volume of work performed is relatively high (note that a hypertrophic response would be most likely if the initial set were performed within the hypertrophy repetition range). This style of supersets can employ two, three (a tri-set) or more exercises (a giant set) for the target muscle group. The greater the number of exercises employed the greater the degree of fatigue experienced and the greater the muscular endurance demanded.

The second variation of supersetting consists of performing two exercises back-to-back that involve antagonistic muscle pairs i.e. biceps brachii / triceps brachii or quadriceps / hamstrings. This version of supersetting allows a significant load to be placed on the target muscle during each set. This is possible because while the agonist is working the antagonist is recovering and vice versa. This allows more intensity to be utilised as each set is performed from a relatively rested state. Fleck and Kraemer (1997) report that significant strength gains have been achieved by individuals trained using this variation of the superset system.

From a commercial point of view both types of supersetting can prove useful to the trainer who only has limited time with certain clients. The lack of rest intervals means that the work element of the session can be completed in less time than usual.

5. Pre-exhaust / post-exhaust

These systems involve the use of isolation exercises to preferentially fatigue a muscle whilst eliminating synergistic muscle weaknesses. Consider the following example:

In the bench press, the agonist is the pectoralis major, with the main synergist being the triceps brachii. In the majority of clients the triceps will fail before the stronger pectoral muscles. By employing either a pre or post exhaust isolation exercise it is possible to “bypass” the weak synergist and permit greater fatigue of the target muscle – in this example pectoralis major.

In pre-exhaust the pectoral isolation exercise is performed prior to the compound e.g. cable crossovers performed before bench press.

In post-exhaust the pectoral isolation exercise is performed after the compound e.g. bench press performed before cable crossovers.

Both methods result in the primary target muscle, the pectorals, doing more work than if regular bench press was performed by itself.

Guidelines for developing pre and post-exhaust routines are listed with some examples in the table on the following page:

Pre-exhaust – guidelines and examples		
• select a target muscle – this muscle must act as the main prime mover in at least one compound exercise • select an isolation (single joint) exercise for the target muscle • select a compound (multi-joint) exercise for the target muscle **then either:** • perform the desired number of sets of the isolation exercise, then move on to perform sets of the compound exercise (normal rest intervals apply) **or** • perform the isolation exercise immediately followed by the compound exercise (this is an example of a pre-exhaust superset). Rest between supersets and repeat as required		
Muscle group	Isolation exercise	Compound exercise
Pectoralis major	Cable crossover	Bench press
Quadriceps	Leg extensions	Squats
Latissimus dorsi	Straight arm pulldown	Lat pulldown
Anterior deltoid	DB front raise	DB shoulder press

Pre-exhaust guidelines and examples

6. Giant and tri sets

This is considered an advanced bodybuilding technique as it is a progression in intensity beyond agonist supersetting. A giant set usually consists of 4 exercises that stimulate the same muscle group in slightly different ways that are performed back to back without any rest. An example of a giant set for the latissimus dorsi muscles of the back may include the following exercises:

- bent over barbell row
- lat pulldown
- seated cable row
- single arm dumbbell row

The giant set would consist of performing a complete set of each exercise in order with no rest. After the full cycle of 4 exercises the client would then have 2-3 minutes rest to recover and repeat the giant set again through two more cycles with rest in between.

Another method of training similar to the giant set is tri set training. This works on the same principles as a giant set, only three exercises are used in the exercise cycle instead of four.

7. Matrix ('21s')

This method of training is one of the first training systems that most gym users are exposed to, normally in the form of "21s" for bicep curls.

The matrix system can be utilised when performing most resistance exercises and involves breaking a rep down into three distinct phases - normally described as outer range, inner range and full range. Each phase is performed for 7 reps, giving a total of 21 reps, hence the name "21s" being synonymous with the matrix method.

A set of "21s" for bicep curls would be performed as follows:

- 7 reps from extension to 90 degrees of elbow flexion
- 7 reps from 90 degrees of elbow flexion to full flexion
- 7 reps full range of movement

The premise of the matrix method is it increases time under tension per set and thus promotes an increase in hypertrophy.

8. Forced/negative reps

It is often the case in resistance training, that we fail concentrically when performing an exercise but actually have some eccentric strength left. That is to say, we may not have the ability to lift a certain weight but may still have the ability to lower the load under control. Potentially, a number of motor units are left unused which, when seeking hypertrophy, might potentially limit some of the gains that would otherwise have been made. In forced reps and negative reps we can overcome this weakness by exaggerating the eccentric phase of an exercise or making the concentric phase slightly easier.

To employ forced reps, the client performs as many reps on his/her own as they can until the point of volitional failure is reached. At this point, the trainer provides a minimal amount of assistance to permit the performance of another rep. As the client fatigues further, the trainer will provide slightly more assistance each rep for a total of 2-4 reps before terminating the set. This process is merely an extension of normal spotting procedures. It is important to note that at no point should the trainer be helping to the degree that they are doing more work than the client! If this is the case, the load is too great or the set has been extended too far beyond failure.

In negative reps, the concentric phase of an exercise is all but removed and all the effort is applied to the eccentric portion of the movement. Potentially this means the client can be exposed to supramaximal loads in excess of their normal repetition maximum. Examples of negative reps include leg extensions where the resistance is raised with two legs but lowered with one, chin/pull ups where the client climbs/jumps into the top position, and lowers themselves slowly into the extended position or a bench press where two spotters are used to lift the bar into the starting position and the client lowers the bar slowly on his/her own.

Clearly both methods are advanced, should not be attempted by novice clients and only performed with the aid of an experienced spotter/trainer. It should be noted that the eccentric portion of any exercise is believed to be the main contributing factor in causing DOMS (delayed onset of muscle soreness). However, this type of training can also result in dramatic increases in strength and cross sectional size when performed judiciously with advanced clients.

Student Task

Design a 3rd phase of training for your client that will help them to achieve their objective of hypertrophy. It must differ significantly from the previous phase and it should include one or more of the training systems that are appropriate for hypertrophy.

Include your training split and design each individual workout in the tables provided below.

NB: take care not to make your workout too intense as severe DOMS can be expected after a dramatic change in exercise intensity and volume!

Split routine							
Week	Mon	Tue	Wed	Thur	Fri	Sat	Sun
1							
2							

Exercise	Sets x reps	Recovery	System
	X		
	X		
	X		
	X		
	X		
	X		
	X		
	X		
	X		

Exercise	Sets x reps	Recovery	System
	X		
	X		
	X		
	X		
	X		
	X		
	X		
	X		
	X		

Exercise	Sets x reps	Recovery	System
	X		
	X		
	X		
	X		
	X		
	X		
	X		
	X		
	X		

Exercise	Sets x reps	Recovery	System
	x		
	x		
	x		
	x		
	x		
	x		
	x		
	x		
	x		

Conflicting training goals

As mentioned previously, one of the principle variables in the success of any hypertrophy programme is recovery. The frequency of workouts is an important factor in the recovery process. If a workout is repeated too frequently the ability of the body to recover from the exercise stimulus will be limited.

An equally important factor affecting the ability to recover is the amount of other physical activity or exercise the client performs on a regular basis. Often individuals that train for hypertrophy include too many other types of physical activity. It is common for individuals to train with weights several times a week and also go running on a regular basis, or play football at the weekend and attend midweek training sessions.

If an individual has a training goal that is as specific as hypertrophy they will need to dedicate the vast majority of their physical resources towards achieving this aim. It is impossible for individuals to obtain significant results across a number of components of fitness simultaneously. Training methods that induce beneficial adaptations in one component of fitness may produce negative effects on another ability or physiological system (Zatsiorsky, 1995). For example, strength and hypertrophy gains obtained through intense resistance training may have a negative impact on aerobic fitness and vice versa. If hypertrophy is the key training objective a minimal volume of other modes of exercise is recommended.

Designing strength and power resistance based programmes

Muscular strength is commonly defined as the ability of muscles to generate maximal force and is often expressed in terms of 1RM or one repetition maximum. It should be noted that muscles are able to demonstrate maximal force production in a variety of different situations. These include concentric, eccentric and isometric contractions, as well as any variety of movement speed velocities for the isotonic actions (Knuttgen and Komi, 1992).

Development of muscular strength can be of benefit for a wide range of athletic endeavours as well as many every day situations. Competitive powerlifting (1RM squat, deadlift and bench press) is perhaps the ultimate expression of pure strength in a competitive context. Lifting heavy objects from the floor and placing them on a high shelf may be an example of an everyday situation where a reasonable degree of functional strength is required.

Power however, is also a key component of neuromuscular conditioning. Power is determined by the rate at which the body can generate force.

Power can be defined as:

$$\text{Power} = \frac{(\text{Force x Distance})}{\text{Time}}$$

Power can be considered as the amount of work done divided by the time taken to do it. More simply, power is the 'rate of doing work.'

Moving the same load over a consistent distance in half the time requires an individual to double the effort in terms of power output.

Uses of power in everyday life

Mention power in the gymnasium environment and people will naturally think of elite athletes participating in sports and events such as sprinting, jumping and Olympic weightlifting (clean and jerk, snatch). Because of the perception that power is for elite athletes only, many individuals never even consider power training. These widely held beliefs about power and power training are unfortunate as they cause many individuals to miss out on a valuable and enjoyable area of resistance training.

Although most individuals will never be required to perform a long jump, throw a javelin or complete a competitive clean and jerk, everybody will perform tasks on a daily basis that require some degree of power. The rapid force development required for someone to run up a flight of stairs demonstrates the application of power to an every day task.

Strength and power contraindications

Whilst strength and power training is suitable for the majority of the population, some special care groups should not perform this kind of work:

- hypertensives (implications of the use of valsalva manoeuvre)
- osteoarthritis/rheumatoid arthritis
- pregnancy
- severe osteoporosis
- obesity

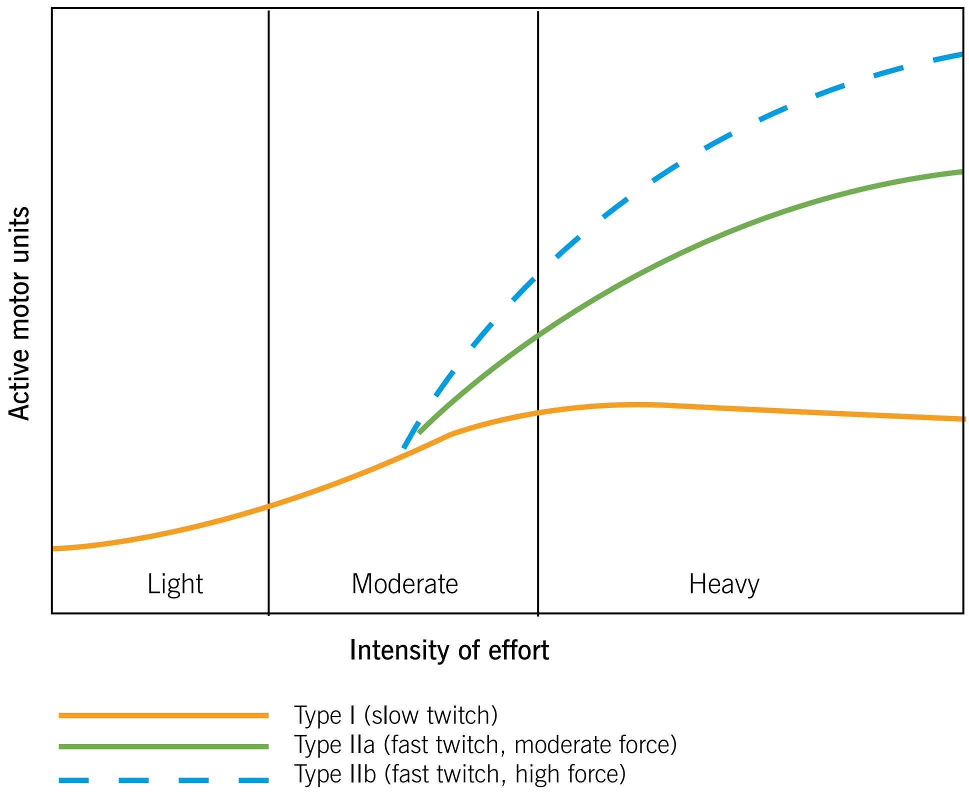
Factors affecting the development of strength and power

There are several independent factors that influence the ability of an individual to develop force production and thus express strength. Certain factors are inherent and not modifiable. These include genetics as well as biomechanical considerations, such as lever length and muscle insertion points. There are some key influential factors that can be modified by the individual wishing to develop strength:

1. Neural factors

Motor unit recruitment:

- during a physical task, motor units will be sequentially recruited from weakest to strongest as the force requirement of the task increases (McArdle et al, 2001)
- the highest force motor units (fast twitch, type IIb) are only recruited significantly during high intensity muscular contractions



Motor unit recruitment during different intensity muscular contractions (adapted from McArdle et al, 2001)

Research suggests that untrained individuals may only be able to recruit approximately 60% of their available motor units during a maximal voluntary contraction. In comparison, highly trained strength athletes have demonstrated the ability to synchronously activate 85% or more of all motor units during a maximal contraction (Hartmann and Tunnemann, 1995). As motor units are sequentially recruited from weakest to strongest as the force requirement of the task increases, untrained individuals are often unable to utilise their most powerful type IIb motor units as they have rarely been called upon to fire.

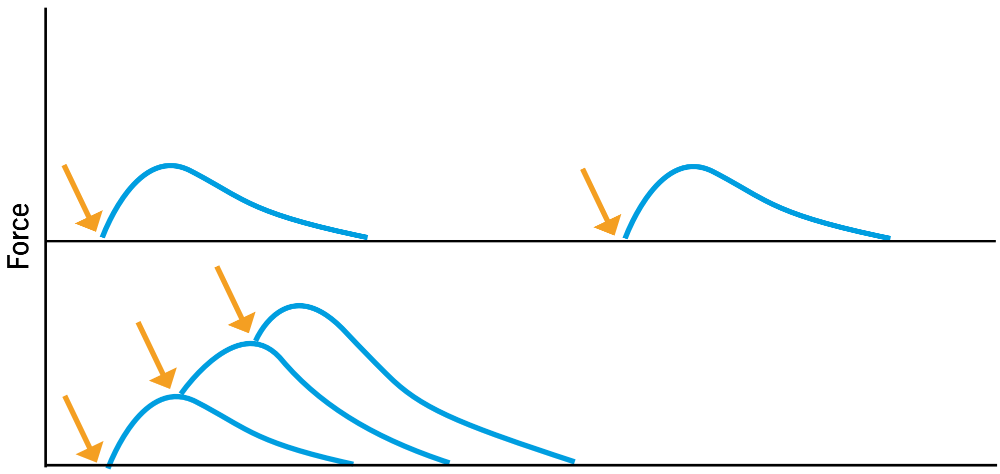
Motor unit synchronisation:

- motor units should fire in a synchronous manner in order to produce smooth, accurate movements (Zatsiorsky,1995)
- in highly experienced power and strength athletes there is evidence to suggest that motor units are activated in a more synchronised fashion during maximal voluntary contractions
- synchronised summation of force from the majority of available motor units results in increased force production

It is also worth remembering that strength increases as the client develops a more efficient motor pattern for the desired movement (intermuscular co-ordination).

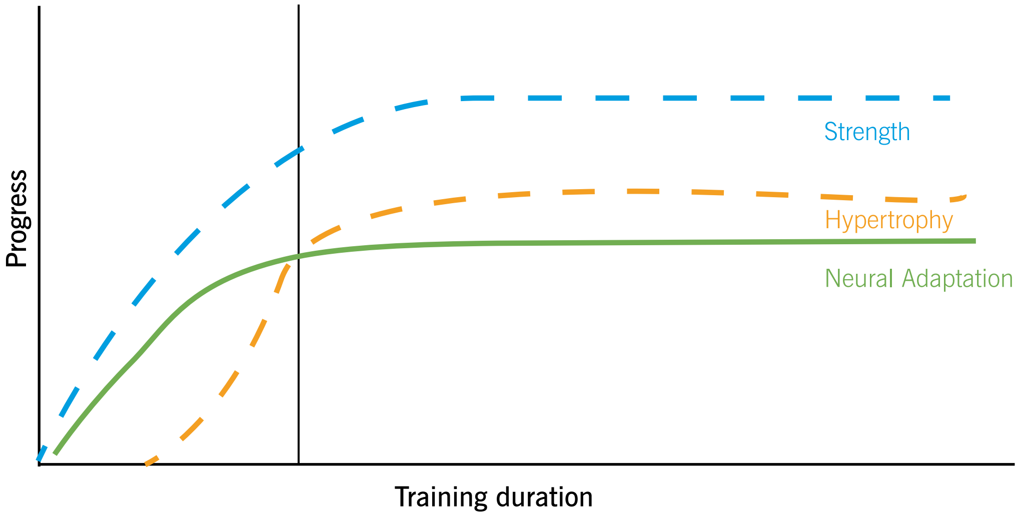
Increased frequency of nervous stimulation (rate coding):

As well as recruiting additional motor units, the body can increase force production by increasing the frequency of stimulatory impulses to the active muscle fibres. By increasing the rate of nervous impulses to each motor unit the nervous system can initiate additional contractions before the tension generated from the initial contraction has dissipated. In this way, the second contraction is added to the tension of the first, resulting in greater strength (Hartmann and Tunnemann, 1995).



A *infrequent nervous impulses,* **B** *increased rate coding*

Once an individual reaches a more advanced training age, their ability to recruit available motor units is maximised. Any further gains in strength are predominantly the result of increased contractile protein levels within the muscle (hypertrophy). This concept justifies the inclusion of hypertrophy phases in the long-term training schedules of individuals training for strength.



Adapted from McArdle, Katch and Katch (2001). Factors leading to strength gains in general trainers and elite athletes

Repetition speed:
The speed at which repetitions are performed is an important variable in force development. In many athletic endeavours the ability to produce force rapidly is of paramount importance. Zatsiorsky (1995) suggests that the effects of a strength based exercise are highly dependent on the movement velocity at which that exercise is performed. If, therefore, a client is training to improve strength for a specific sport, the trainer should analyse the movement speeds required for that sport and programme accordingly.

2. Muscular factors

Muscle fibre type:
It is well documented that fast twitch muscle fibres are able to generate more force than slow twitch fibres (McArdle et al, 2001). Robergs and Roberts (1997) suggest that drastic changes in fibre type proportions are unobtainable through voluntary muscular contractions (training). As such it would seem that fibre type proportions, along with factors such as lever length and insertion points, contribute significantly to strength but are largely unmodifiable through exercise.

Hypertrophy:
While it may not be possible to significantly alter the fibre composition of an individual through exercise, it is universally accepted that individual fibres can increase in size as a result of appropriate resistance training (McArdle et al, 2001). An increase in the cross-sectional area of muscle is associated with increased strength. This is as a result of increased actin / myosin cross-bridging interaction.

Musculoskeletal factors – leverage:

If two individuals have identical musculature (fibre type, motor unit recruitment, force production capabilities), but one has more favourable levers, then this individual will demonstrate greater levels of maximal strength (expressed as total resistance lifted – 1RM). Due to the inherent variation in leverage exhibited by individuals, it is suggested that comparisons of strength levels between individuals can be de-motivational for certain clients. A better option for the trainer would be to monitor the progress of a client over time i.e. compare current strength levels to previous performances.

3. Nutrition and fatigue

Current nutritional status has such a far-reaching impact on all of the systems of the body that it would be difficult to overstate its importance. Appropriate nutrition provides energy, enables growth and repair of tissues and optimises mood / mental function. Disrupting any of these factors may limit the ability of an individual to train and express strength. As a result of its wide reaching influence on the body, it is imperative that trainers consider nutrition to be equally as important as exercise when it comes to developing the strength levels of their clients.

If training is too intense, too long, too frequent, or performed over time with inadequate nutrition, the individual will start to accumulate fatigue. In the short term, fatigue will prevent optimal physical performance. In the long term, fatigue can lead to overtraining and all of the detrimental consequences that go along with it. Appropriately applying overload to the client while planning adequate recovery periods between workouts will allow the trainer to minimise the risk of short term and accumulative fatigue.

Training for strength

Following the principle of exercise specificity, in order to get stronger a client needs to lift progressively heavier loads over time.

Intensity, reps and sets

The type of training required to develop muscular strength is characterised by maximal or near maximal training intensities. For the purposes of this chapter, intensity will be expressed as a percentage of 1RM so that, the closer to the 1RM, the more intense the exercise.

The guideline for strength training intensity is to perform high intensity sets, performed at 85% or more of 1RM. It is important to remember that this is a general guideline only.

Characteristic	Strength
Intensity	High
Load as % of 1RM	>85%
Reps	1-5
Recovery between sets	3-5 minutes
Sets per exercise	2-6
Frequency per muscle group	1-2 x per week

Adapted from Baechle and Earle (2000)

Exercise selection

Exercise selection will significantly influence the results experienced by clients participating in strength and power training programmes. The majority of the exercises chosen should be compound, multi-joint exercises. This type of exercise utilises multiple large muscle groups and requires the recruitment of a high number of fast twitch motor units when performed at high intensities. The exercises that will have the greatest strength developing effects are those that stress the largest muscle groups i.e. the musculature of the upper legs, gluteals and back. Each session should focus on one to three key lifts. Many powerlifting workouts consist of one key lift (squat, deadlift or bench press) followed by a small amount of work on assistance exercises.

When training to develop muscular strength it is more appropriate to overload the movement pattern as opposed to individually fatiguing the individual muscles involved in that movement. Zatsiorsky (1995) suggests that isolation exercises should only be used as a supplement to the main training programme when focusing on strength.

Student Task

Select 5 free weight exercises that stress the musculature of the upper legs, gluteals and back, and are appropriate for near maximal intensities.

Exercise	Muscles used

Programming for strength

When planning to train for strength over a period of time, the trainer can take the general repetition guideline (1-5 reps per set) and split it into two further subsections. The trainer can plan a basic strength phase consisting of sets of 4-5 repetitions, followed by a more intensive maximal strength phase of 1-3 repetitions per set.

The basic strength phase provides the client with an introduction to the strength training intensity and volume, without requiring the maximal intensity effort involved in 1RM attempts. In this way, trainers are able to utilise the principles of periodisation by logically applying increments in intensity to the strength training sessions of their clients.

It is highly recommended that the client has spent time progressively moving through the stages of resistance training prior to attempting a basic strength phase.

Characteristic	Basic strength	Maximal strength
Intensity	High	High
Load (%1RM)	>85% 1RM	>93% 1RM
Reps	4-5	1-3
Recovery	2-5 mins	2-5 mins
Sets per exercise	2-6	2-6

Recommendations for basic and maximal strength programme design (rep max % from Baechle and Earle 2000)

Student Task

Design 2 basic strength workouts that would be suitable for a client with an extensive resistance training background. The client wants 2 workouts that can be alternated as part of a 3 times per week training phase focusing on the acquisition of basic strength.

Your workout should cover the whole body and incorporate exercises, sets, reps and recovery periods that are conducive to the development of basic strength.

Exercises – Workout A	Sets x reps	Recovery

Exercises – Workout B	Sets x reps	Recovery

Progressing to maximal strength

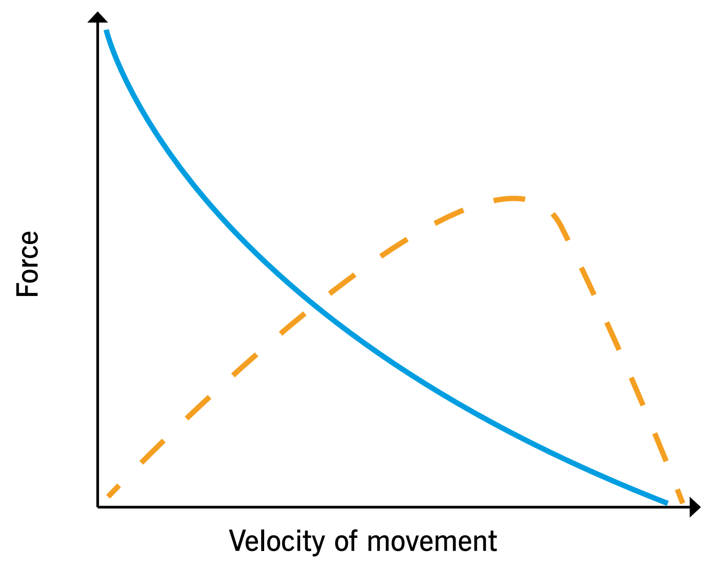
Maximal strength training is only suitable for clients involved in sporting activities where either maximal loads are handled (e.g. weight lifting) or where high degrees of strength are expressed (e.g. rugby). For the majority of the general training population, maximal training presents too high a risk of sustaining serious injury.

Before placing a client on a maximal strength programme, the trainer must ask them selves if the potential benefit of this type of training exceeds the potential risk. If the risk outweighs the benefit, then maximal strength training is probably an unnecessary phase of training for the client in question and strength for all or basic strength parameters will yield sufficient results at a much lower risk.

Progressing to power

The key difference between strength and power training is the speed of movement, or the intent of the speed of movement used to perform the exercises. Power training requires the client to attempt to move the weight or load as quickly as possible.

If the load is relatively low the individual will be able to accelerate through the range of movement easily and the movement speed will be significant (see force/velocity curve). Subsequently, the body will adapt and movement velocity will increase. On the other hand, training with maximum loads will increase maximum force output without necessarily increasing velocity (especially if a large degree of strength has already been gained). Ideally, for power training the participant should be able to release the load (throw it), or leave contact with the ground, as in jumping, hopping and bounding drills. This practice allows the participant to accelerate throughout the entire movement, thus maximising power. Maximal power occurs around 30% of maximal load and two-thirds of maximal velocity.



Force / velocity relationship
Power

Relationship between force and velocity

Holding on to the load may not bring about optimal gains in power. The vast majority of free weight exercises do not allow the individual to release the weight. This inevitably encourages the neuromuscular system to learn to decelerate the load towards the end of the range of movement. This may limit power transfer into the movement. Traditional free weight exercises definitely have a place in the build up to power training as they promote enhanced force development, however dedicated power exercises will push client's power fitness on to new levels of performance.

Power programme design - basic power training principles

The following principles should be applied to all power type exercises to ensure that maximal benefit can be derived from this type of training. Apply the following principles to all power training modalities:

- employ a specific graduated warm up with includes exercise rehearsals
- power movements should only be performed using perfect technique
- movements should be performed with intent of speed (EXPLODE!)
- deceleration of training implemented at end range of movement is to be avoided
- sets typically last under 10 seconds and should certainly last no longer than 15 seconds with no drop off in performance
- recovery should be full or close to full (3 minutes +)
- quality of exercise execution should be emphasised over quantity of volume performed

Personal training outside the gym

Personal training need not be limited to a health club or the gym environment. Training for fitness across a wide variety of clientele and objectives can be successfully performed in other locations and environments. The personal trainers (PT's) foremost concern when training a client in any situation is the safety of the session. Training a client outside of a gym in different exercise environments requires the PT to plan for many more potential health and safety concerns. It is important that they consider having the following available:

- emergency procedure
- First Aid kit
- mobile phone
- emergency contacts list
- environment check list
- incident book

If an incident was to take place, the PT would have to prove that they took reasonable steps to prevent the incident and deal with it once it occurred. Having all of the above will show that appropriate levels of care and consideration have been taken. The incident book will also show that the trainer is monitoring the safety of different venues and environments and taking proactive steps to avoid dangers.

Personal training in other environments may pose a number of potential risks. The environments where personal training may be successfully performed include:

- client or trainers home
- public park or countryside
- public street
- community or village hall
- clients place of work
- beach
- sports hall, arena or stadium

Student Task

Choose 3 of the above potential locations and list 3 potential dangers/risks that may occur at any of the above venues.

Venue	Potential dangers
	1 2 3
	1 2 3
	1 2 3

When selecting equipment to purchase for an outside of the gym-based training situation the PT needs to be able to evaluate how much value they will get from each piece of equipment. Some items of equipment can only provide a few simple exercises, whilst others have great versatility and as such may be used across multiple training formats and exercises. The following is a list of questions that should be asked about equipment before purchase:

- size and weight
- ease of carriage
- cost and investment value
- versatility

Size and ease of carriage will be an issue to a trainer who travels between client homes, as they will have to consider how much equipment they can take with them. Also, the time considerations that are associated with setting up and packing away may affect the income potential of the trainer. For PTs who are intending to work in the city, transporting equipment may be an issue, especially if they have to travel by foot or public transport.

Many pieces of equipment on the market are sold at a high price but have a limited use and versatility. This can increase the amount of equipment that the trainer has to carry with them and directly affect the session quality. A trainer, for example, needs to ensure that each session is dynamic and slick so it is important to keep equipment changes to a minimum.

Student Task

Identify equipment suitable for a travelling trainer to take around and deliver personal training sessions in client homes and compare to equipment that may not be suitable

Suitable for home PT		Not suitable for home PT	
Training equipment	Approx. cost	Training equipment	Approx. cost

Programming

Planning a session for an outdoor activity requires the PT to go through the same procedure as they would in a gym-based programme:

- programme designed to achieve the client's goal
- effective warm up to get the client prepared for the upcoming activity
- a main session that is goal related, has the correct exercise order and is designed for a great client experience
- effective cool down that takes the environment into consideration

After the session has been delivered the PT would be required to go through the post-session paperwork, recording issues such as changes in the programme, booking the next session and in between session contacts.

Pre-session information

Prior to the session taking place the PT needs to make sure that they have collected all of the relevant information in order to deliver the program safely and effectively. The following is a list of pre-session information that must be collected:

- personal training contract
- disclaimer
- PAR-Q
- lifestyle analysis
- test results
- goal setting records
- periodised programme agreement
- location specifics
- safety considerations
- environmental advantages to be exploited

It is important for the PT to apply their knowledge of exercise selection, reps, sets, loads, tempo's and exercise order to match goals and in whatever environment they find themselves. If, for example, a client wants to improve their strength and the training is taking place in a park, then the PT needs to find ways of challenging the client within the specific strength repetition range using bodyweight or manual resistance.

Using bodyweight or manual resistance in an exercise instead of free weights or bands will not change the principles of the exercise or its technique. For example, an alternative to a standing cable pull using manual resistance may mean the PT using their own strength and a towel to work with the client to perform the exercise, however, the technique does not change.

Training principles and objectives

It is important to understand that despite a change of location to a different environment other than the gym the same basic training principles apply to any successful fitness programme. However, some training objectives can be a little more difficult to achieve without the equipment and safety that a gym environment provides, such as training for strength. Cardiovascular ability, endurance and power are often easy to train and deliver beyond the walls of a fitness facility. Hypertrophy can be achieved when training is carefully planned, but once again the need for larger loads can hinder it somewhat. There are many training modalities that can work superbly in other training environments such as a park, a client's garden or a community hall. These include but are not limited to:

- circuit training
- endurance training
- supersetting
- bodyweight training
- medicine ball training
- manual resistance training
- agility and quickness training
- proprioceptive training

Designing 'solo' routines for clients

The PT will likely need the client to perform certain tasks on their own in order to help them achieve their goals. Therefore, the client will need to perform their training programme independently when the PT is not present. In this case, the PT should be aware of the following:

- the health and safety risks of exercises performed without a PT
- availability of equipment to the client
- potential cost of client purchasing small equipment
- appropriate exercise selection and alternatives
- clients who adapt their own programs

In designing such a solo program for a client, it is advisable to err on the side of safety and choose stable and low risk activities, particularly in the beginning as the client is becoming accustomed to the training environment and challenge. As the client becomes more assured and capable the trainer will be able to raise the exercise stimulus with trust in the client's abilities when they train by themselves.

Periodisation

Definition

'Periodisation':

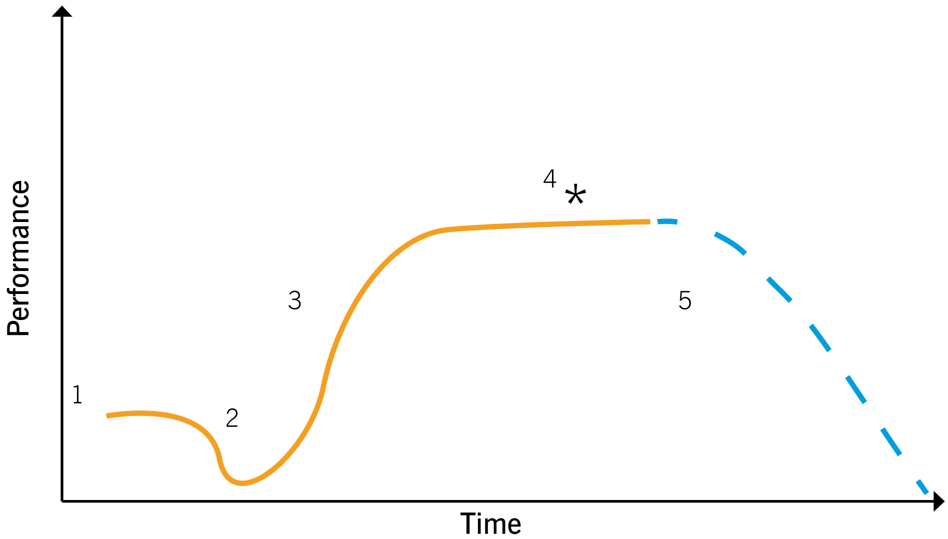
> *"This term originates from period, which is a portion or division of time into smaller, easy-to-manage segments, called phases of training." (Bompa, 1999)*

When planning resistance training programmes, variety is a key factor in long term progression. A fundamental mistake of many trainers is to assume that there is one 'magic' workout that will deliver results to all of their clients. This approach is extremely limited and unproductive in the long term.

Resistance training programmes can be separated into training blocks that can be performed for a period of time in order to elicit an adaptive response. These blocks of training can be referred to as training phases or cycles.

Each training phase can be viewed as a stressor that the body needs to cope with. The way in which the human body reacts to a stressor over time has been famously explained by Hans Seyle (Wathen et al, 2000). Seyle's General Adaptation Syndrome (GAS), although not originally designed for exercise, has been used to explain the need for variation within training programmes. The figure below provides a graphic depiction of the GAS.

GAS - Adaptive responses to a new stimulus / stressor



1. Stressor (new training phase)
2. Alarm phase
3. Adaptation phase
4. Plateau
5. Exhaustion phase - can lead to overtraining (if initial stressor continues with no scheduled rest)

1 * rest should be introduced here, followed by a new training stimulus

The General Adaptation Syndrome

The GAS starts with the introduction of a stimulus (exercise programme) that is novel or new to the individual (Kraemer, 2004). Initially, this new stimulus will lead to a decrease in performance during a period known as the alarm phase. This phase may last several days to several weeks. During this period, the client may experience fatigue, stiffness and soreness and a temporary drop in physical performance (Wathen et al, 2000).

If the individual is able to cope with the new stimulus (i.e. survive it), the alarm phase will be followed by a period of adaptation. During the adaptive phase the body initiates a variety of biochemical, neural, structural and mechanical adjustments that lead to enhanced physical performance (Wathen et al, 2000). After a period of continuous exposure to the same stimulus, the rate of adaptation will slow down and eventually reach a plateau (Kraemer, 2004). Once a plateau has been reached continued exposure to the stimulus will result in the exhaustion phase. This is due to the inability of the body to tolerate the cumulative stress of the same stimulus over a period of time (Kraemer, 2004; Wathen et al, 2000).

The exhaustion phase is characterised by a decrease in physical performance, as well as monotony, soreness and fatigue (Wathen et al, 2000). Continuing to apply the same stimulus through the exhaustion phase can eventually lead to a number of detrimental conditions. If the training stimulus is not removed or altered, or if active rest is not promoted, the client can become sick, injured or experience acute overtraining (Kraemer, 2004).

The key aim of any periodised programme should therefore, be to maximise the adaptation phase and avoid exposure to the exhaustion phase. In order to achieve these aims, the trainer must ensure that periods of rest are scheduled into the periodised programme, and that the stimulus is changed on a regular basis. If the body is allowed a brief period of recuperation at the end of each training phase, it will be primed to receive and adapt to the next progressive training stimulus.

It is also important to mention at this stage that persevering with the same stimulus over a period of time may lead to a lack of progress for another reason. If an individual fails to change a workout significantly over a period of time and consistently fails to work hard within each workout session, the stimulus may not be significant enough to elicit an alarm stage (see GAS). This scenario would lead to a lack of progress, as there is no challenging stimulus that would necessitate adaptation within the body. Realistically, this situation is more common than clients consistently flirting with the overtraining scenario.

Applying periodisation

Practical application of periodisation requires the phasic manipulation of intensity and volume in order to build towards an overall objective. As discussed previously, it is not physiologically possible to continue to adapt to a training stimulus indefinitely. Attempting to do so is likely to lead to mental boredom, physical fatigue, decline in performance, injury and overtraining.

The trainer should be aware that a long term training p eriod (e.g. a training year) could be broken down into distinct phases. Traditionally, using the periodisation model, the long term training period can be split into the following phases or cycles.

- macrocycle
- mesocycle
- microcycle

Macro and mesocycles

The macrocycle is the largest division of the periodised training schedule. The macrocycle is generally an expression of the overall training objective of the client. When training for sports or athletic events a macrocycle will typically last for a year, although it can be longer. Elite athletes will often employ a four year macrocycle plan that builds towards an Olympic or world championship event. The macrocycle, or long term objective, can be broken down into a series of progressive mesocycles. Typically, a mesocycle will last several weeks to several months (Wathen et al, 2000). It is the mesocycle that is often referred to as a training phase.

A typical training phase should generally last 4-8 weeks. However, novice clients may continue to achieve progress on a new stimulus for longer periods (i.e. 8 weeks plus) whereas, very advanced clients may require shorter training phases in order to sustain progression, (i.e. 4 weeks or less). As well as adhering to the majority of the research based advice regarding phase length, the 4-8 week training phase guideline fits conveniently into the calendar monthly cycle. This can make the various training cycles easier to track and potentially easier to sell from a commercial point of view.

By strategically varying the objective of each training phase the trainer can build logically towards the overall macrocycle objective. Simplistically, this progression should follow the basic progression pyramid approach as outlined previously. The client needs to 'earn the right' to progress to the top of the pyramid by performing the base layers first. The general sequence of endurance, hypertrophy, and strength should be adhered to.

Creating variation across each of the training phases should follow a logical approach. Key points to consider are making the intensity and volume increments manageable. For example, it would not be advisable to progress from a basic whole body endurance programme straight into a full hypertrophy based split routine. The jump in volume and intensity would be too much to handle.

Implementing changes from one training phase to the next affords the trainer the opportunity to demonstrate an understanding of the periodisation concept. The table below shows set and rep schemes for the different resistance training objectives, however it should be noted that these are guidelines only and should be adapted to meet the requirements of the individual client.

Training goal	Strength	Hypertrophy	Endurance
Intensity	High	Moderate	Low
Load as % of 1 RM	>85%	67-85%	<67%
Reps / duration	1-5	6-12	12+
Recovery between sets	3-5 mins	1-2 mins	30-60 seconds
Sets per exercise	2-6	3-6	2-3
Frequency per muscle group	1-2 x per week	1-2 x per week	2-3 x per week

Resistance training guidelines

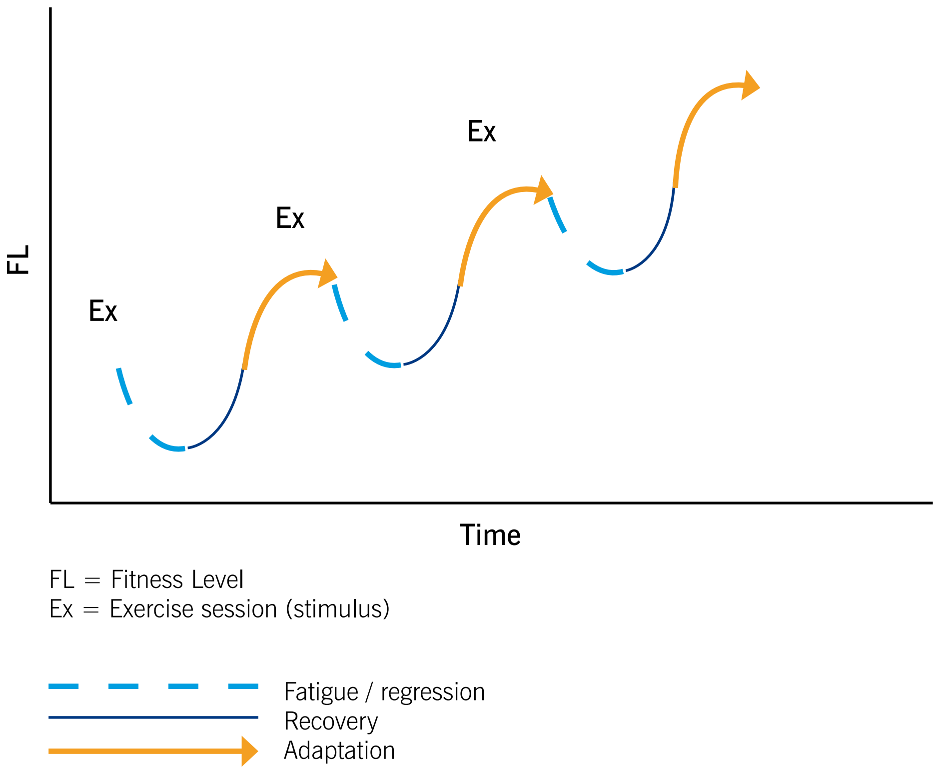
Microcycles

Each 4-8 week mesocycle can be further broken down into microcycles, with each microcycle typically lasting for 1 week (Wathen et al, 2000). This short term training cycle consists of the rotation of weekly workouts, as well as the day-to-day intensity and volume manipulations that drive the client towards their overall long term objectives.

Stimulus-fatigue-recovery-adaptation model

When planning a resistance-training programme it is vital that the trainer understands the importance of recovering between workouts. The diagram below illustrates how the fitness capacity of the body responds to a series of appropriately spaced resistance training sessions.

Enhanced fitness level



Stimulus-fatigue-recovery-adaptation model

The stimulus-fatigue-recovery-adaptation model suggests the processes that the body goes through in order to attain an elevated fitness level within the confines of a microcycle (i.e. from workout to workout). The stimulus (the workout) induces fatigue in the individual while simultaneously initiating a series of underlying physiological mechanisms i.e. biochemical, neural, hormonal (Stone, 2004). During the recovery phase these physiological mechanisms promote adaptations that allow the individual to perform at a higher level. This adaptation can be termed 'supercompensation' (Zatsiorsky, 1995). This process is dependent on three key variables:

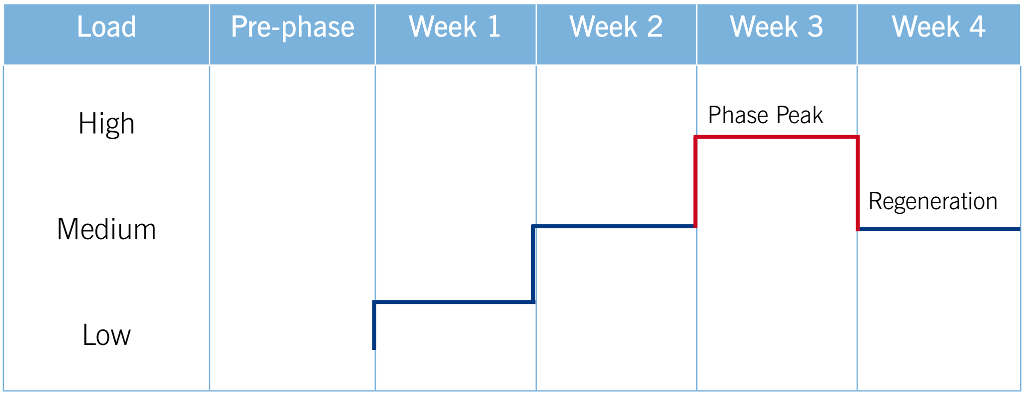
- the stimulus must be sufficient to cause fatigue and induce an adaptation (i.e. overload must be incrementally applied within the microcycles)
- the recovery timeframe (i.e. the time between workouts) must be adequate to allow recovery and adaptation
- the nutrition of the individual must be sufficient to support both the training and the recovery processes

Microcycles - variable progressions

The principle of progressive overload suggests that the client should strive to improve their previous workout performance on a regular basis. This could mean achieving one extra repetition, or performing the same number of reps with a marginally heavier load.

Short term or microcycle progressions can be planned much in the same way as a sequence of progressive training phases. There are various short term loading patterns that can be used to achieve progress. Some popular examples have been given below.

Step loading patterns



Step loading – adapted from Bompa (1999).

In the above step loading example the microcycle intensity manipulations for any given exercise could be progressed as follows:

Deadlift – workout frequency = 2 x per week			
Week	Sets	Reps	Load
1	4	12	80kg
2	4	12	82.5kg
3	4	12	85kg
4	2	12	82.5

Step loading set and rep progression

Note the following points within this weekly microcycle progression pattern:

- the resistance increments are very small from week to week – this is vital to allow progression
- the client is exposed to the same stimulus twice prior to an intensity increase. This is to allow enough time for adaptation to occur
- the final week of this training phase (week 4) is a recuperation week. The volume of work is decreased to allow some recovery. In this example, the intensity has also been decreased slightly. The recuperation week allows the next phase to be tackled with regenerated adaptive reserves

Recovery weeks

If a client has trained through a prolonged series of progressive training phases, a complete recovery week (or longer) is advisable. During this time, the body is allowed to fully recuperate from the rigors of the extended resistance training effort.

If the trainer schedules recovery weeks into long term exercise programmes, certain activities and behaviours can be advocated to promote recovery. Massage, flexibility sessions or moderate non-resistance-based activities (e.g. swimming, walking) can all be promoted during the rest period. Also, the client should be reminded about the importance of appropriate nutrition during recovery as well as during the training phases. Adequate sleep patterns and stress management techniques can also help the clients fully recover from a period of hard resistance training.

Student Task

1. **Plan a periodised training year for your own training. Use the table below to fill in your planned progression over time. Start from the current month and work from your current level of fitness towards your overall objective**

2. **Design 2 workouts from any 2 of your phases of training**

Rep range	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Phase exercises	Sets x reps	Recovery	Notes
	x		
	x		
	x		
	x		
	x		
	x		
	x		
	x		

Supplementary notes

Phase exercises	Sets x reps	Recovery	Notes
	X		
	X		
	X		
	X		
	X		
	X		
	X		
	X		

Supplementary notes

Training logs

In order to deliver a thorough and professional service, the trainer should keep detailed training records for each client. These records should be completed during each training session and compiled to produce an accurate training log that charts the progress of the client over time.

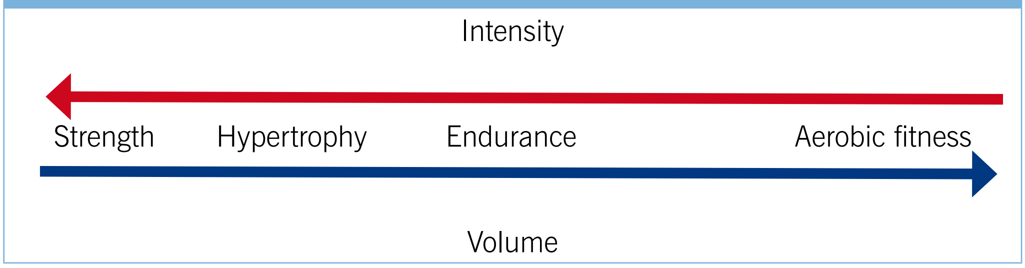
Use of a training log can help to achieve success by recording performance and allowing progressive overload to be applied appropriately.

Combining aerobic training with resistance training

Most clients are not elite athletes and are therefore unlikely to require an ultra-specific approach to their training. The average client will generally benefit from a mixed training approach that incorporates both resistance and aerobic exercise. Accommodating both modes of training is a challenge that the trainer must deal with during the programme design process.

Training hard for aerobic fitness gains is a conflicting exercise stimulus if the client has an overall objective of muscular strength or hypertrophy. This is because these components of fitness place diametrically opposite demands on the body (see table below). Simultaneously attempting to train maximally for both strength and aerobic fitness will lead to less than optimal results for both components of fitness.

Intensity / volume continuum



If the client has an overall objective that is resistance-based, such as strength or hypertrophy, the majority of the training effort should be resistance-based. The trainer should focus on manipulating the resistance training variables appropriately as the phases progress in order to move the client closer to their goal. When performed concurrently with intense resistance training, a high volume of aerobic training would negatively impinge on recovery and adaptation processes, thus limiting progress.

There are stages in the overall training macrocycle (long term plan) when a higher volume of aerobic training can be incorporated. If the trainer follows the principles of periodisation and manipulates the intensity of resistance training over time, there will be phases when the intensity is lower (endurance phases). Endurance and aerobic training are not hugely conflicting goals and may actually complement each other.

Resistance intensity	Aerobic volume	
Low	Moderate / high	
Moderate	Low / moderate	
Moderate / high	Low	

Rep range	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
4-6												
6-8												
8-10												
10-12												
12-15												
15-20												

The table above shows how aerobic training can be incorporated into an annual training programme geared towards hypertrophy. Note how the aerobic volume decreases as the resistance intensity increases. This will give the client a greater chance to recover from the intense hypertrophy training sessions, thus maximising growth potential.

If the objective has an aerobic focus then the same principles will apply in reverse. Resistance training volume and intensity will decrease as the aerobic phases become more challenging.

It is advisable to include some resistance training in the programme of an aerobically orientated client, just as clients with resistance-based goals should include a minimal amount of aerobic conditioning. The trainer may initially have to convince the client as to the benefits of a cross training approach, and then ensure that the volume and intensity of both training modes are manipulated appropriately to ensure optimal results.

Safely training special populations

Introduction

Special considerations when designing a programme may need to be given to certain population groups within the exercise environment.

It is important for the PT to understand changes that the musculoskeletal system undertakes through the ageing process and in pre and post-natal women. A basic understanding of these changes will allow a better understanding of the implications for exercise when dealing with such populations.

Contraindications and safety guidelines

Contraindications exist whenever there is an increased risk of harm in any given activity and may exist regardless of age. If any should be identified during the client screening process (PAR-Q, Health Commitment Statement or similar) appropriate action should be taken. This is normally by means of a GP referral. The PT is then given guidance on any action the medical authority deems appropriate.

Young people

Changes in the musculoskeletal system

As children grow, muscle mass steadily increases during the developing years. At birth approximately 25% of a child's body weight is muscle mass, and by adulthood about 40% of a person's total body mass is muscle (Faigenbaum, 2000). During puberty an increase in hormone production is the main driver for these increases. The increases will be at a greater rate in boys than girls throughout adolescence due to hormonal differences.

Growth spurt: at some stage during a child's maturation their bones will suddenly develop at a rapid rate. This is known as a growth spurt. Growths spurts happen at different rates and ages, but commonly:

- for girls between the ages of 10 and 12, growing fastest at 12 to 13. The spurt normally ends at 18
- for boys between the ages of 12 and 14, growing fastest at 14 to 15. They tend to end their growth spurt later at the age of 20

A concern with children is the vulnerability of growth cartilage to trauma and overuse (Micheli, 1995). These type of injuries can disrupt the bone's blood and nutrient supply resulting in permanent growth disturbances. In an adult it is not uncommon for ligament injuries to occur as a result of repetitive stress or direct trauma from a fall. In a child these may represent themselves in an epiphyseal growth plate fracture.

Growth plate fractures are more common in boys than girls with the greatest incidence occurring among 14-16 year old boys and 11-13 year old girls. The weakest area of the growing skeleton is the growth plate and so a serious injury to a joint is more likely to damage the growth plate than the ligaments.

Key guidelines for training young people

Preventative measures to avoid 'growth-related injuries':

- it is extremely important to avoid excessive training. These include playing too much of one sport, playing the wrong sport for their body type and using too heavy a weight in weight training
- it is important to remember the gender differences and the differing stages of development within the same sex
- inappropriate size matching in pairs should be avoided
- avoid repetetive loads and too many high impact moves on the spot
- always teach an appropriate warm up and cool down
- always provide appropriate equipment for the activity (correct size, weight etc)

Flexibility in relation to children

Caution should be taken when teaching any stretch exercise especially when children are in the growth spurts. These are really vulnerable times and there is an increased injury risk as the soft tissue around the joints is already stretched as muscle growth does not keep up with bone growth rates.

Younger children will not have gained enough motor skills to develop their flexibility with good technique and risk injury by not understanding stretching to the point of 'mild tension'. Instructors should, therefore, encourage children not to overstretch.

Aerobic capacity

One would expect the aerobic capacity of a child to increase with age due to the lung and heart capacity increasing. This is true in absolute terms. VO_2max measured in L/min increases from 6 – 18 years for boys and 6 – 14 years for girls. However, when VO_2max is normalised using body weight, little change is observed with age. There is a slight decline after puberty in girls because of the increase in body fat rather than muscle mass, while VO_2 max slightly increases at puberty for boys as a result of their increase in muscle mass.

It is not a child's VO_2max that limits their endurance performance. Instead, children lack technique and end up with poor economy in activities such as running. Children have shorter limbs and less muscle mass which results in lower mechanical power. In the growth spurts, they have disproportionately long legs meaning that they are biomechanically out of balance and are potentially less coordinated.

Body temperature and dehydration

Physiologically children have an inferior cooling mechanism due to low blood volume and high skin temperature. They are sensitive to heat stress because they expend more energy per kilogram of bodyweight than an adult. Adolescents therefore, are at risk of dehydration when exercising due to overheating.

In the cold, children lose heat more quickly due to their relatively large surface area compared to their mass (in relation to their physical development compared to an adult).

The implications for the instructor are:

- give regular water breaks
- the warm up component may need to be less intense and shorter than an adults
- the cool down component may need to be shorter than an adults
- active rests may have to be given between bouts of vigorous activity

Anaerobic exercise

The anaerobic capacity of both boys and girls increases with age, but is not fully developed until around 20 years of age. Due to their lack of muscle mass and smaller livers children have less glycogen stored per gram of muscle and have fewer stores of creatine phosphate than an adult. They are therefore, unable to generate as much anaerobic work.

This means that the natural fatigue mechanisms from intense work that adults possess do not exist to the same degree with children. This, along with the fact that they overheat more than adults are the major risk factors that instructors need to be aware of when training young adolescents at high intensities, since while they appear to keep going their muscles will still be fatigued and they will overheat.

An adolescent would not normally require any power training incorporated in their programme, but sometimes, as part of their sport, it can be considered appropriate. Preadolescents and adolescents should avoid power lifting, body building, and maximal lifts until they reach physical and skeletal maturity (American Academy for Pediatrics, 2008).

Older adults

Changes in the musculoskeletal system

From 35 to 40 years of age there is a gradual loss of bone (Borner et al, 1988 cited in Cech and Martin, 2002). Osteopenia is a condition where bone mineral density is lower than normal and is often a sign of ageing. It is considered by many to be a precursor to osteoporosis. Osteoporosis is a disease characterised by low bone mass and deterioration of bone tissue leading to enhanced bone fragility and a subsequent increase in the risk of fracture. Osteoporosis occurs in both males and females but is more common in females.

Bone development is dependent upon the presence of hormones. In women this is the female hormone, oestrogen, and in men it is the male hormone, testosterone. These hormones influence the formation of bone by promoting the activity of bone building cells called osteoblasts. The body replaces around 10% of its bone a year as long as osteoblasts are active (Dalgleish and Dollery, 2001). However, if osteoclast cells, which destroy or break down old bone, are more active than osteoblasts bone mass will start to decrease.

Further effects of ageing are a reduction in joint range of movement (ROM), a thickening of ligaments, a loss of elasticity of connective tissue and muscle, and wear and tear to cartilage found on bone ends, leading to degenerative changes to joint structures.

Neuromuscular changes: a large percentage of the elderly find difficulty in simply standing from a seated position due to an age-related decline in muscle functioning. Ageing leads to a decrease in the number of functioning fast twitch (FT) muscle fibres and an increase in functioning slow twitch (ST) muscle fibres. Advancing age is also associated with a loss of muscle mass, known as sarcopenia. Resistance training is highly recommended to reduce the ageing effects on the neuromuscular system.

Regular weight-bearing exercise has been shown to help maintain and build up bone mass. The stronger muscles, better balance and agility to which exercise contributes can also help in fall prevention. The type of exercise should be tailored to the individual's needs and abilities. People with osteoporosis must take special care when exercising to reduce the risk of fracture due to impact or falls.

Key safety guidelines for training older people

This guidance relates to clients aged 50 and over. 50 is the current internationally recognised age at which there is significant reduction in the safety margins relating to exercise and when pre-exercise screening is essential to ensure exercise professionals meet their duty of care.

These best practice guidelines are for 50+ individuals who:

- are asymptomatic (i.e. determined by the pre-exercise completion and interpretation of one of the two recommended 50+ pre-exercise Screening Tools namely: Revised PAR-Q (PARQ-R) or the AHA/ACSM Health/Fitness Facility Pre-participation Screening Questionnaire)
- have little or no recent and frequent experience of the particular exercise modality

Relaxation of these guidelines for highly trained, recently and frequently, physically active asymptomatic individuals in a particular exercise modality is at the clients own risk. However, the instructor needs to be mindful that regardless of the older adult's fitness levels and outward appearance, the ageing process is underway.

40 is the approximate age at which the ageing process begins and 50 is the age at which the progressive losses in the musculoskeletal/CV/neuromuscular systems means that adaptation of exercise needs to be considered. Highly trained individuals in the 50+ age range are a very small and elite group accounting for approximately 1% of the 50+ population.

Due to the vulnerable nature of the musculoskeletal system, associated with the ageing process, the PT should be cautious when dealing with this population. Although weight-bearing exercises are recommended, low impact exercise is generally favoured to avoid unnecessary trauma to the skeletal and muscular systems.

To be safe (i.e. to reduce/minimise the risk of adverse, age-related cardiovascular and articular system events to a minimum) the following guidelines should be followed for adults age 50+:

- current international guidance (ACSM/AHA) recommends that all people over the age of 50 should complete a recommended pre-exercise health screening questionnaire (PARQ-R or AHA/ACSM) to establish whether they are asymptomatic and ready to participate or whether they should seek further medical assessment prior to participating in an exercise programme

- spend longer warming up and warm up more gradually than younger clients (i.e. to ensure a total of 15 minutes) and begin with moderate shoulder circles before increasing the shoulder ROM and progressing to arm circles). Clients should be advised to do this by taking responsibility for themselves e.g. by walking to the session or by coming early and warming up before the session

- build-in a longer, more gradually tapered cool down after the aerobic training. Clients should be advised to do this by taking responsibility for themselves e.g. by keeping going for a few minutes after the rest of the class have stopped and/or are changing to the next activity (i.e. to prevent/minimise the potential for adverse cardiovascular events)

- keep the intensity of all training components to a challenging but health related level i.e. without pain or strain and within their individual 'personal best training zone' by using the talk-test and educating clients on the use of the RPE scale as a means of monitoring and regulating exercise intensity, as required.(N.B. it should be challenging)

In addition, where appropriate, instructors should encourage 50+ clients to:

- ensure correct technique as it is even more important for injury prevention with this client group
- take more time during transitions e.g. floor to standing
- simplify exercise. When correct technique cannot be maintained and risk is increased e.g. when any weight bearing steps involving laterally crossing one leg over the other (e.g. grapevine) are included in a group session, the instructor should use their professional judgement (including the clients current physical activity history) before giving suitable alternatives to the older person e.g. adapt the grapevine by bringing the feet together with turns of more than 90 degrees, while breaking the movement down into stages, can prevent dizziness until fitness improves
- learn new exercises with the easiest position and/or the lightest resistance and progress slowly initially
- avoid extreme spinal flexion (i.e. full or half curl-ups from supine) and make abdominal training more challenging and safer for the vertebrae by keeping the neck long and if lifting off the floor, supported by the arm

Pre and post-natal women

Changes in the musculoskeletal system

During pregnancy, relaxin (a hormone released in the second trimester) softens ligaments, cartilage and the cervix, allowing these tissues to lenghten during delivery. This particularly assists the required movement at the pubis symphysis and the sacroiliac joint. The effects of relaxin mean that joints throughout the body are potentially vulnerable and therefore, should not be overly stressed, for example, through over-vigorous stretching.

In both the pre and post-natal periods exercises should be given to strengthen the pelvic floor muscles. As the uterus grows, these muscles become overly stressed and start to sag. This can cause several potential problems not least of which is stress incontinence (National Kidney Foundation, 2002), i.e. the leaking of urine, since these muscles control the bladder.

Careful screening of every expectant mother wishing to exercise during pregnancy or shortly after should be carried out. If there is any doubt regarding the appropriateness of exercise, the mother to be should be referred to the GP. In any case, the mother will receive regular check ups from the GP or midwife who will, amongst other things, monitor their blood pressure and answer any health concerns they may have.

Post-birth, the ACOG (1994) recommend that women should avoid all physical stress for two weeks (i.e. 'don't carry anything heavier than the baby') and not resume full daily activities for a minimum of six weeks after delivery. It is also advised that those who delivered by Caesarean section should not exercise for 12 weeks after delivery to allow proper healing time.

Exactly how long relaxin stays in the body post-birth is up for debate and will vary between mothers. Five months is often quoted although estimates vary from three months up to a year. In reality, the hormone can be present for as long as the mother is breast-feeding, which may be up to two years. The mother is the best judge and will know when she no longer 'feels loose'.

Key guidelines for training pre and post-natal clients

This information relates only to normal, healthy, adult women experiencing a normal, healthy, single pregnancy, or who have had a normal, healthy birth, and have had previous normal, healthy pregnancies and births.

In most cases, exercise is safe for both mother and baby. Exercise at appropriate intensity for the individual concerned is not associated with adverse pregnancy outcome.

Women who have not exercised prior to pregnancy should begin with 15 minutes continuous aerobic activity, increasing gradually to 30 minutes continuous low-moderate intensity aerobic activity.

Pregnant women should maintain adequate hydration during exercise, avoid exercising in very hot or humid conditions, consume adequate calories and restrict exercise sessions to no longer than 45 minutes, according to recommended guidelines.

Heart rate should not be used to monitor exercise intensity during pregnancy. Women should be advised to exercise according to how they are feeling and be encouraged to use the talk-test to monitor appropriate, individual intensity.

Pregnant women should avoid:

- exercising in the supine position after 16 weeks of pregnancy. The inclined position is unlikely to be a successful alternative to flat supine
- exercising prone
- prolonged, motionless standing
- heavy, uncontrolled, isometric or prolonged resistance work above the head
- leg adduction and abduction against a resistance
- isometric exercises
- loaded forward flexion
- rapid changes of direction or position
- uncontrolled twisting
- exercise with a risk of falling or abdominal trauma
- excessive and uncontrolled de-stabilisation techniques

Pregnant women should immediately stop exercising if they experience:

- dizziness, faintness or nausea
- bleeding or leakage of amniotic fluid
- abdominal or contraction type pain
- unexplained pain in the back, pelvis, groin, buttocks or legs
- excessive shortness of breath, chest pain or palpitations

Hormonal and postural changes make pregnant women vulnerable to injury, joint misalignment, muscle imbalance and motor skill decline, especially if they are genetically hypermobile. These changes may start from very early on in pregnancy and gradually become more significant as pregnancy progresses.

Women in the child-bearing period are habitually forward flexed with shoulder girdle protraction, thoracic kyphosis, long, weak upper back extensors, and short tight pectoral muscles and are prone to neck and shoulder pain.

Certain conditions, such as air embolism, thrombosis and haemorrhage, have elevated risk during the first weeks post-birth. Women should not begin exercising post-birth until they have received the permission of their health care professional, usually at the post-partum 6 to 8 week check.

The physiological and postural changes of pregnancy may last beyond birth for several months, making women vulnerable to injury and long-term physical health problems such as pelvic floor dysfunction. This has particular significance for exercise involving impact, twisting and rapid, ballistic or aggressive movements, which should be avoided for at least 6 months and introduced progressively. High intensity or impact exercise in pregnancy and post-birth carries the risk of long term pelvic floor muscle (PFM) support and control dysfunction.

Ideally, post-birth, women should be encouraged to re-educate posture, joint alignment, muscle imbalances, stability, motor skills, transversus abdominis muscle recruitment and PFM function before progressing to more vigorous exercise.

“Sit up”, “crunch” or “oblique cross-over” type exercises are not an appropriate choice for abdominal muscle re-education post-birth.*

*For at least 12 months post-birth rectus abdominis is mechanically weaker (Coldron, 2007). Excessive oblique’s training may cause downward pressure through the pelvic floor (O'Dwyer, 2008) and anatomically will probably cause lateral pull on a weaker linea alba. TA and PFMs are unlikely to be recruiting effectively to provide adequate abdominal compression and support.

A woman should be referred to a health professional if she is experiencing any of the following symptoms post-birth:

- stress incontinence or pelvic floor muscle weakness
- "dragging" pain or a feeling of heaviness in the lower abdominal or pelvic floor area
- groin, low back pain or difficulty walking, even if mild and intermittent
- abdominal muscle weakness, excessive abdominal doming, abdominal muscle separation or softness/sinking at the umbilical mid-line, umbilical hernia

Instructors should be aware that women in the childbearing period are vulnerable to injury, nausea, dizziness and fainting. Instructors should therefore have up to date first aid skills.

Key guidelines for training disabled people

Many disabled people find they experience barriers to accessing sufficient physical exercise for psychological, physical or social reasons.

It is widely recognised that regular and planned physical activity in a safe and supportive environment may not only help disabled clients in the same range of ways as for non-disabled clients, but it may also reduce the risk of gaining additional disabling conditions, improve the ability to perform activities of daily living that might previously have been difficult, and maintain or even improve independence.

> *"Joining a fitness centre is an excellent way for persons with disabilities and health limitations to maintain their physical function after rehabilitation or to improve their overall health in a supervised setting where they can benefit from the assistance of a qualified fitness professional." (Fitness Management, September 2001)*

However, a recent study has, showed that the majority of subjects with mobility limitations felt that fitness centres typically do not have the type of equipment or professional staff needed to assist them properly (Rimmer et al., 1999).

Physical disabilities

When considering the limitations and additional safety guidelines which may be required to programme design for a disabled client, the instructor needs to appreciate that, because of the various kinds of disabilities, describing specific components of an exercise prescription for each condition can be difficult.

Some physical disabilities are classified as progressive e.g. multiple sclerosis. This means that the condition will worsen over time. Progressive disorders require careful monitoring to ensure that the exercise program is not causing the condition to worsen (exacerbation).

Sometimes physical disabilities exhibit asymmetrical weakness e.g. stroke, cerebral palsy. If there is a difference in strength between the left and right side of the body the fitness professional should aim to improve the affected side as much as possible without neglecting the side which is unaffected however, if the nerves controlling the affected side have been partially or completely damaged, the ability to improve in the affected muscles is greatly reduced.

Spasticity

Spastic muscles are very tight or rigid. Since many individuals with physical disabilities will have some degree of spasticity, flexibility training is critical. However, before incorporating any flexibility in a programme the instructor should seek authorisation from a suitably trained medical authority on how to stretch a spastic muscle without causing injury.

Neurological conditions

For example: muscular dystrophy.

Muscles can become progressively weaker as a result of the decline in CNS functioning. To help offset this, the programme should try to work on general fitness levels. However should there be any rapid decline in function the client should immediately be referred to their GP for guidance.

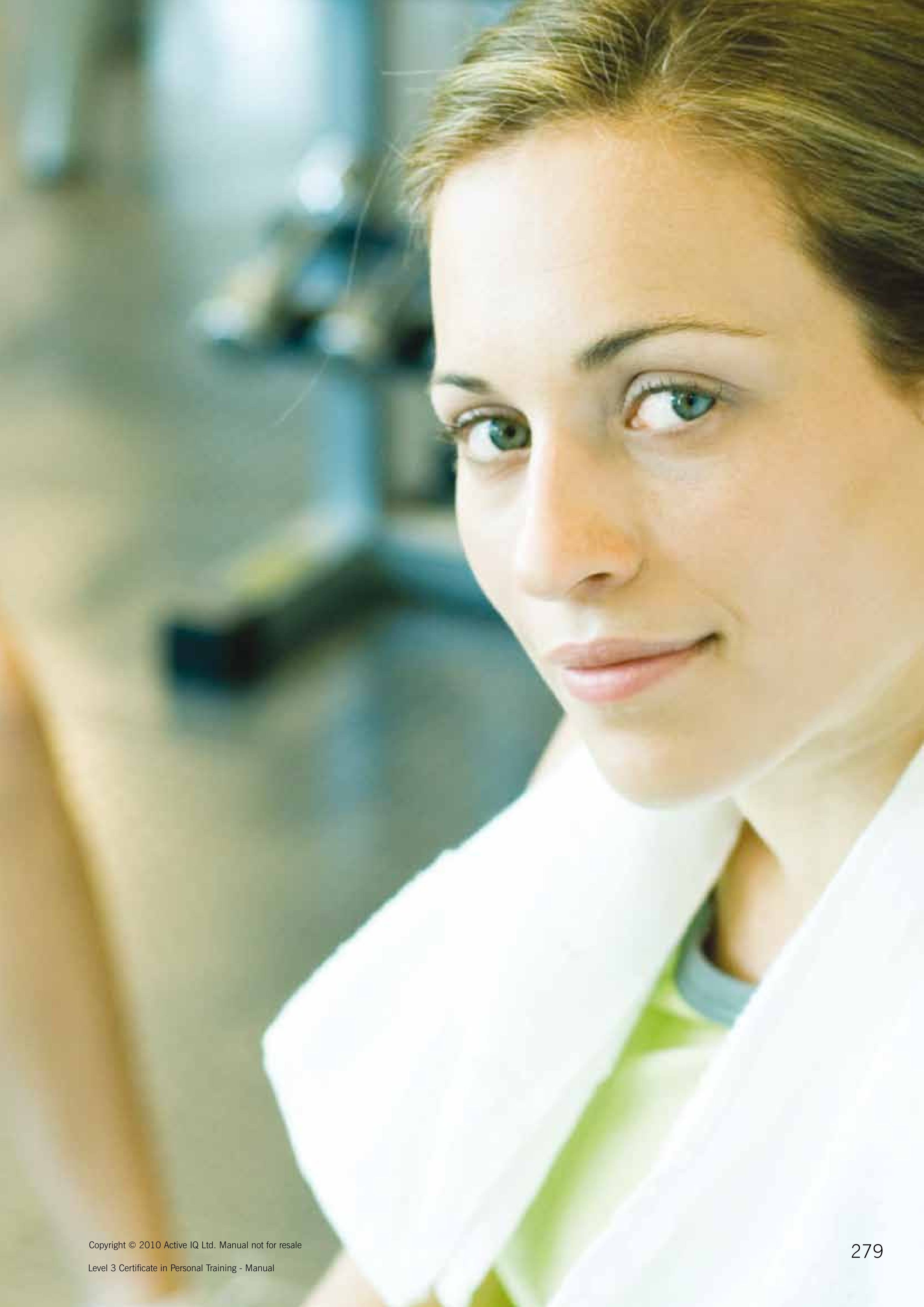
Damage to sensory nerves

This occurs with many types of physical disabilities. Since this may result in an inability to detect pressure against the skin, left untreated, this can result in a pressure sore. It is generally recognised that the use of a wheelchair increases the risk of developing pressure sores, and so the client will already be aware of the importance of frequent checks. However, the instructor should also make the client aware that the use of gym equipment may also bring similar associated risks and so extra checks should be made.

Depression

Depression is a common secondary condition resulting from the physical and psychological challenges of living with a disability. Occasionally, depression can cause a person to drop out of the programme.

It should be noted that these are only some of the common conditions the fitness professional who works with disabled people will experience and, if they are in any way in doubt as to their abilities to work safely and effectively with anyone, they should refer to a medical authority for guidance.



Appendix 1 - Static health tests

Resting heart rate

Resting heart rate (RHR) is the amount of times your heart rate beats every minute at rest. Resting heart rate averages about 60-80 (Heyward, 2002) and is measured in beats per minute (bpm).

Resting heart rate (bpm) references		
	Men	**Women**
Normal	60 - 80	60 - 80
Average	70	75
Special attention	$\geq$ 90	$\geq$ 90
Medical referral	$\geq$ 100	$\geq$ 100

Adapted from Heyward, 2002 and Cotton, 1997

A RHR of less than 60 bpm is called bradycardia and may be the result of good aerobic fitness, hypothermia, low thyroid function, and certain medications.

A RHR of greater than 100 bpm is called tachycardia and may be the result of taking stimulants like caffeine, excess stress, fever, poor aerobic fitness and certain medications.

Resting heart rate – method of assessment
(adapted from Franklin, 2000)

1. Ensure that that your client has rested for 5 to 10 minutes in a seated or supine position, prior to measuring heart rate.
2. Locate the correct site of the carotid or radial artery. These are the most commonly used sites.
3. Use the tips of the middle and index fingers to gently locate the artery. Do not use your thumb; it has a pulse of its own and may produce an inaccurate count.
4. Allow 30 seconds for your client to get used to your measurement and relax.
5. Count pulse for 60 seconds, record the result and repeat for accuracy.

Locations of peripheral pulse (adapted from Latin, 1998)

Carotid

The common carotid artery sites are located on both sides of the front of the neck. Each are in the groove formed by the larynx (Adam's apple) and the sternocleidomastoid muscles (muscles on the side of the neck) just below the mandible (lower jawbone).

Radial

The radial artery courses deeply on the anterolateral (thumb side) aspect of the forearm and becomes superficial near the distal head of the radius (directly in line with the base of the thumb).

Blood pressure

BUPA (2002) describes blood pressure (BP) as "a measure of the force that the blood applies to the walls of the arteries as it flows through them". It is measured in millimetres of mercury (mmHg) and is expressed using two numbers, written as 120/80mmHg ("one hundred and twenty over eighty"). These two numbers represent the systolic and diastolic blood pressures respectively.

Systolic blood pressure

The systolic blood pressure (SBP) is the pressure exerted on the artery walls, when the cardiac muscle is contracting (ventricular systole) and pumping blood. This is the higher of the two numbers, and is usually noted first.

Diastolic blood pressure

The diastolic blood pressure (DBP) is the pressure exerted on the artery walls, when the heart is in a relaxed state. The heart goes through this period of relaxation, or diastole, to allow the chambers of the heart to fill with blood prior to contraction. "The DBP is the running or 'remaining' pressure between beats" (NHS, 2002) and is always smaller than the SBP.

Optimal blood pressure

The ACSM define optimal blood pressure, with respect to cardiovascular risk, as being below 120 mmHg for systolic and 80 mmHg for diastolic pressure (Franklin (ed.), 2000).

Factors that increase blood pressure		
	Acute (immediate)	**Chronic (long term)**
Systolic	• stress, anxiety or arousal • physical activity / exertion • food • caffeine • smoking • illicit drugs**	• psychological stress/anxiety • sedentary lifestyle/inactivity • obesity • high dietary salt (Na) intake low dietary potassium (K) intake • excessive alcohol intake • certain medications/drugs
Diastolic	• heavy weight training • isometric exercise	• psychological stress/anxiety • sedentary lifestyle/inactivity • obesity • high dietary salt (Na) intake • low dietary potassium (K) intake • excessive alcohol intake • certain medications/drugs

Classification of bloodpressure (mmHg) foradults (18+)*			
BP classification	SBP		DBP
Clinical hypotension	< 100	and	< 60
Normal (optimal)	< 120	and	< 80
Normal (pre-hypertension)	120 – 139	or	80 - 89
Hypertension Stage 1 **(special attention)**	140 – 159	or	90 - 99
Stage 2 **(medical referral)**	≥ 160	or	≥100

Adapted from the Seventh Report of the JNC, 2003

Blood pressure is most commonly taken using a sphygmomanometer and stethoscope or an electrical monitor that are becoming increasingly popular today. Good practice denotes that it is taken on the left arm with the cuff around the humerus and the stethoscope placed at the crease of the elbow.

Guidelines for taking blood pressure *(Reeves, 1995)*

1. Ensure that your client has been relaxed for at least five minutes. The client's arm should be restriction free, bare and resting at a 45 degree angle, supported on a flat surface at heart height the palm is facing up.

2. Palpate the brachial artery and wrap the deflated cuff firmly around the upper arm so that the midline of the cuff is directly over the located pulse. The edge of the cuff should be approximately 2.5cm (1inch) above the inner elbow crease.

3. Ensure the cuff is snug around the arm, if it is too loose then BP will be underestimated.

4. Position the earpieces of the stethoscope so that they are aligned with the auditory canals (i.e. angled anteriorly).

5. Place the head (bell) of the stethoscope over the brachial pulse, but not under the cuff. Make certain that the entire head of the stethoscope is in contact with the skin without too much heavy pressure.

6. Close the valve, by rotating the switch clockwise and quickly and steadily inflate the cuff pressure to 20-30 mmHg above the estimated systolic value. This will collapse the brachial artery and there will be no blood flow.

7. Partially open the valve, by turning the switch anti-clockwise slightly, and slowly deflate the cuff at a constant rate of 2-3 mmHg/sec.

8. The first sharp thud caused by the sudden rush of blood as the artery opens (the arterial pressure and cuff pressure are equal) corresponds to the systolic BP.

9. Continue to reduce the pressure at a constant rate. As soon as the pulsing sound becomes muffled and disappears the cuff pressure is equal to the diastolic pressure and normal blood flow is restored – this is the diastolic BP.

Body composition – skinfold analysis

Skinfold measurement is one of the most popular and practical options for measuring body composition. The method is reasonably accurate and cheap to use. Skinfold measurements correlate well (r = 0.70-0.90) with body composition determined by more accurate and costly methods such as hydrostatic weighing (ACSM, 1996). However, it requires considerable practice for a trainer to become proficient and some clients may regard it as too invasive. The method is based on the fact that superficial deposits of body fat at various locations correlate well with total body fat.

Identifying skinfold sites

A description of the skinfold sites (Durnin and Wormersley, 1974) is listed below. The values obtained from the four sites are added together and entered into tables to convert to percentage body fat.

Triceps - a vertical fold on the posterior mid line of the upper arm, measured exactly halfway between the posterior acromion on the scapula and olecranon process of the ulna

Biceps - a vertical fold on the anterior mid line of the upper arm over the biceps muscle, located 1 cm higher than the level used to mark the triceps

Subscapular – a angled fold taken 2 cm below the inferior angle of the scapula and angled at 45º rising up towards the spine

Suprailiac – an almost horizontal, slightly oblique fold taken 1-2 cm above and parallel to the iliac or pelvic crest and in line with the anterior axilla or most anterior point of the armpit

Procedures for using skinfold callipers
1. Take all measurements on the left side of the body (English normative data - left, American - right). 2. Anatomical land marking needs to measured and marked up accurately. 3. Place the thumb and index finger of the left hand 8cm apart just above the landmark and gather up the full skinfold and hold away from the body throughout the full measuring process. 4. Place the jaws of the calliper perpendicular to the skinfold directly on the landmark about half the depth of the fold. Release the jaw pressure slowly. 5. The dial is read as accurately as possible 1-2 seconds after the grip has been released and the jaws of the calliper have come to rest on the skinfold. 6. Open the jaws of the calliper and remove before finally releasing skinfold from between thumb and finger. 7. Take a minimum of two measurements at each site to confirm accuracy rotating around the sites between measures rather than consecutive measures at the same site. *(Adapted from Franklin, 2000 and Heyward, 2002)*

Once each of the skinfold sites has been measured and checked the trainer then determines the total of all 4 skinfold measures in millimetres. This total is then compared to the correct gender normative data table and cross referenced to the correct age range. This will provide an estimate of their current body fat percentage. Body fat percentage can then be used to determine the clients overall lean mass and body fat mass. This data can provide more information for future reference when the client has made changes to their body composition. The following example will demonstrate this. A 34 year old female client weighing 78kg has the following skinfold measurements:

Triceps	25mm	
Biceps	14mm	
Subscapular	18mm	
Suprailiac	28mm	
Total	85mm	which according to norms tables is 35.12% body fat

This means initially 27.4kg is body fat and 50.6kg is lean tissue. 3 months later her body weight was 75kg. Her skinfold measurements were tested again:

Triceps	19mm	
Biceps	11mm	
Subscapular	13mm	
Suprailiac	21mm	
Total	64mm	which according to norms tables is 31.65% body fat

This now means 23.7kg is body fat, a loss of 3.7kg, and 51.3kg is lean tissue, an increase of 0.7kg! This shows that the she has lost even more body fat that the weighing scales have indicated as she has gained lean tissue.

WOMEN % FAT FOR SUM OF SKINFOLD MEASUREMENTS AT ALL FOUR SITES					
Sum of skinfold sites (mm	Age (years)				
	17 - 19	20 - 29	30 - 39	40 - 49	50 +
10	3.46	4.88	8.72	11.71	12.88
12	5.70	7.27	10.85	13.81	15.10
14	7.62	9.30	12.68	15.59	16.99
16	9.29	11.08	14.27	17.15	18.65
18	10.77	12.66	15.68	18.54	20.11
20	12.10	14.08	16.95	19.78	21.44
22	13.32	15.38	18.10	20.92	22.64
24	14.43	16.57	19.16	21.95	23.74
26	15.46	17.67	20.14	22.91	24.76
28	16.42	18.69	21.05	23.80	25.71
30	17.31	19.64	21.90	24.64	26.59
32	18.15	20.54	22.70	25.42	27.42
34	18.94	21.39	23.45	26.16	28.21
36	19.69	22.19	24.16	26.85	28.95
38	20.40	22.95	24.84	27.51	29.65
40	21.08	23.67	25.48	28.14	30.32
42	21.72	24.36	26.09	28.74	30.96
44	22.34	25.02	26.68	29.32	31.57
46	22.93	25.65	27.24	29.87	32.15
48	23.50	26.26	27.78	30.39	32.71
50	24.04	26.84	28.30	30.90	33.25
55	25.32	28.21	29.51	32.09	34.51
60	26.49	29.46	30.62	33.17	35.67
65	27.58	30.62	31.65	34.18	36.74
70	28.58	31.70	32.60	35.11	37.74
75	29.53	32.71	33.49	35.99	38.67
80	30.41	33.66	34.33	36.81	39.54
85	31.24	34.55	35.12	37.58	40.36
90	32.03	35.40	35.87	38.31	41.14
95	32.78	36.20	36.58	39.00	41.88
100	33.49	36.97	37.25	39.66	42.59
110	34.82	38.39	38.51	40.89	43.90
120	36.04	39.70	39.66	42.02	45.10
130	37.17	40.91	40.73	43.06	46.22
140	38.22	42.04	41.72	44.03	47.25
150	39.20	43.09	42.65	44.94	48.22
160	40.12	44.08	43.52	45.79	49.13
170	40.99	45.01	44.34	46.59	49.98
180	41.81	45.89	45.12	47.35	50.79
190	42.59	46.73	45.85	48.07	51.56
200	43.33	47.53	46.55	48.75	52.29

MEN % FAT FOR SUM OF SKINFOLD MEASUREMENTS AT ALL FOUR SITES					
Sum of skinfold sites (mm	Age (years)				
	17 - 19	20 - 29	30 - 39	40 - 49	50 +
10	0.41	0.04	5.05	3.30	2.63
12	2.46	2.10	6.86	5.61	5.20
14	4.21	3.85	8.40	7.58	7.39
16	5.74	5.38	9.74	9.31	9.31
18	7.10	6.74	10.93	10.84	11.02
20	8.32	7.96	12.00	12.22	12.55
22	9.43	9.07	12.97	13.47	13.95
24	10.45	10.09	13.87	14.62	15.23
26	11.39	11.03	14.69	15.68	16.42
28	12.26	11.91	15.46	16.67	17.53
30	13.07	12.73	16.17	17.60	18.56
32	13.84	13.49	16.84	18.47	19.53
34	14.56	14.22	17.47	19.28	20.44
36	15.25	14.90	18.07	20.06	21.31
38	15.89	15.55	18.63	20.79	22.13
40	16.51	16.17	19.17	21.49	22.92
42	17.10	16.76	19.69	22.16	23.66
44	17.66	17.32	20.18	22.80	24.38
46	18.20	17.86	20.65	23.41	25.06
48	18.71	18.37	21.10	24.00	25.72
50	19.21	18.87	21.53	24.56	26.35
55	20.37	20.04	22.54	25.88	27.83
60	21.44	21.11	23.47	27.09	29.20
65	22.42	22.09	24.33	28.22	30.45
70	23.34	23.01	25.13	29.26	31.63
75	24.20	23.87	25.87	30.23	32.72
80	25.00	24.67	26.57	31.15	33.75
85	25.76	25.43	27.23	32.01	34.72
90	26.47	26.15	27.85	32.83	35.64
95	27.15	26.83	28.44	33.61	36.52
100	27.80	27.48	29.00	34.34	37.35
110	29.00	28.68	30.05	35.72	38.90
120	30.11	29.79	31.01	36.99	40.33
130	31.13	30.82	31.89	38.15	41.65
140	32.08	31.77	32.71	39.24	42.87
150	32.97	32.66	33.48	40.26	44.02
160	33.80	33.49	34.20	41.21	45.10
170	34.59	34.28	34.88	42.11	46.12
180	35.33	35.02	35.53	42.96	47.08
190	36.04	35.73	36.13	43.77	48.00
200	36.71	36.40	36.71	44.54	48.87

Body Mass Index

The Body Mass Index (BMI) is worked out using the following equation:

$$\text{BMI (kg/m}^2\text{)} = \frac{\text{Weight (kg)}}{\text{Height}^2\text{ (m)}}$$

Example: If a 70 Kg man (2.2lbs = 1 Kg) stands 68 inches tall (2.54 cm = 1 inch), then:

$$\text{BMI} = \frac{70\text{ Kg}}{1.72\text{m}^2} = \frac{70}{2.98} = 23.5\text{ kg/m}^2$$

As BMI uses weight only and does not consider body composition, it is not appropriate for measuring fat loss. However, it is useful as a quick method to determine bodyweight compared to national guidelines and as a potential factor for disease risk. The BMI categories are:

Classification of overweight and obesity by Body Mass Index (BMI)			
		Obesity class	BMI (kg/m²)
Underweight			<18.5
Normal	**Acceptable**		18.5 – 24.9
Overweight	**Special attention**		25 - 29.9
Obesity	**Medical referral**	I	30 – 34.9
		II	35 – 39.9
Extreme obesity		III	>40

National Institute of Health, (1998)

This method is particularly inaccurate for individuals who have a higher than normal amount of muscle mass. They will often be classified in overweight categories suggesting an increased risk, which is not correct if they are muscular and still lean. BMI should not be used as a means of monitoring changes in body composition.

Waist to hip ratio

The pattern of body fat distribution is recognised as an important predictor of the health risks of obesity (Van Itallie, 1988). Fat stored around the abdominal region (as opposed to your legs, hips and arms) is considered to be a greater risk factor for CHD. Health risk increases with waist to hip ratio, and standards for risk vary with age and gender. For example:

Classification	Men	Women
High risk	> 1.0	> 0.85
Moderate risk	0.90 – 1.0	0.80 – 0.85
Low risk	< 0.90	< 0.80

Adapted from Van Itallie, (1988)

Appendix 2 - Fitness tests

Cardiovascular tests

Balke treadmill test

Balke and Ware (1959) devised one of the most commonly used treadmill protocols. During the Balke test:

- treadmill speed is set at 3.3 miles per hour (5.3 kilometres per hour) and the initially flat gradient rises to 2%
- increase gradient by 1% with each subsequent minute until the client is unable to maintain the intensity of the exercise

Maximum treadmill time (minutes and fractions of minutes) is directly related to aerobic capacity, and VO_2max can be reliably predicted from the following equation:

VO_2max (ml·kg-1·min-1) = 1.444·(time/60) + 14.99 (Pollock et al., 1976)

For example, a treadmill time of 950 seconds predicts a VO_2max of 37.9 ml·kg-1·min-1[1.444 x (950/60) + 14.99]

- the score can be compared with the VO_2max norms offered in the norms tables

Gradual and equal increments make the Balke protocol suitable for many adults, including older and / or deconditioned individuals. However, the test may be too long for more fit individuals. It should be stressed that, due to the gradual nature of the test, no separate warm up is required.

Fitness categories for males, based on VO_2 max expressed in $ml·kg^{-1}·min^{-1}$					
Age (years)	Low	Fair	Average	Good	High
20–29	≤24	25–33	34–42	43–52	≥53
30–39	≤22	23–30	31–38	39–48	≥49
40–49	≤19	20–26	27–35	36–44	≥45
50–59	≤17	18–24	25–33	34–42	≥43
60–69	≤15	16–22	23–30	31–40	≥41

AHA, American Heart Association (American Heart Association, 1972)

Fitness categories for females, based on VO_2 max expressed in $ml·kg^{-1}·min^{-1}$					
Age (years)	Low	Fair	Average	Good	High
20–29	≤23	24–30	31–37	38–48	≥49
30–39	≤19	20–27	28–33	34–44	≥45
40–49	≤16	17–23	24–30	31–41	≥42
50–59	≤14	15–20	21–27	28–37	≥38
60–69	≤12	13–17	18–23	24–34	≥35

AHA, American Heart Association (American Heart Association, 1972)

Cooper 3-mile walk test

For many individuals, Cooper's 3-mile walk test provides an indication of aerobic fitness without requiring a maximal effort. As a result, the test is suitable for healthy males and females aged 13–70 years who have been actively walking for at least six weeks (Cooper and Storer, 2001). If the course is accurately measured, the test can be performed indoors or outdoors. Participants should be instructed to walk 3 miles as fast as possible without running. Time to completion can be used to assess aerobic fitness, as indicated in the table.

Classification of cardiorespiratory fitness based on Cooper 3-mile walk test (Cooper, 1982). Values represent time (mins) to complete 3-mile walk					
Age (y)	Very poor	Poor	Fair	Good	Excellent
13–19					
Males	≥45:01	45:00–41:01	41:00–37:31	37:30–33:00	≤32:59
Females	≥47:01	47:00–43:01	43:00–39:31	39:30–35:00	≤34:59
20–29					
Males	≥46:01	46:00–42:01	42:00–38:31	38:30–34:00	≤33:59
Females	≥48:01	48:00–44:01	44:00–40:31	40:30–36:00	≤35:59
30–39					
Males	≥49:01	49:00–44:31	44:30–40:01	40:00–35:00	≤34:59
Females	≥51:01	51:00–46:31	46:30–42:01	42:00–37:30	≤37:29
40–49					
Males	≥52:01	52:00–47:01	47:00–42:01	42:00–36:30	≤36:29
Females	≥54:01	54:00–49:01	49:00–44:01	44:00–39:00	≤38:59
50–59					
Males	≥55:01	55:00–50:01	50:00–45:01	45:00–39:00	≤38:59
Females	≥57:01	57:00–52:01	52:00–47:01	47:00–42:00	≤41:59
60+					
Males	≥60:01	60:00–54:01	54:00–48:01	48:00–41:00	≤40:59
Females	≥63:01	63:00–57:01	57:00–51:01	51:00–45:00	≤44:59

Cooper 1.5-mile run test

Aerobic fitness can be assessed using the 1.5-mile run test first described by Cooper in 1968. The test can provide a valid measure of aerobic capacity, but it requires pacing and a sustained, near-maximal effort. For these reasons, at least six weeks' aerobic training (preferably running) is recommended before attempting the test. After warming-up, participants should be instructed to complete the 1.5-mile distance as fast as possible. Time is recorded to the nearest second, and a gradual cool-down should follow the test. Interpret test performance using the tables on the following pages. If the Cooper 1.5-mile run test is performed on a treadmill, the incline should be set at 1% to replicate the energy cost of running outdoors (Jones and Doust, 1996).

Classification of cardiorespiratory fitness based on Cooper 1.5-mile run test (Cooper, 1982). Values represent time (mins) elapsed in completing 1.5 miles						
Age (y)	**Very poor**	**Poor**	**Fair**	**Good**	**Excellent**	**Superior**
13–19						
Males	≥15:31	15:30–12:11	12:10–10:49	10:48–9:41	9:40–8:37	≤8:36
Females	≥18:31	18:30–16:55	16:54–14:31	14:30-12:30	12:29–11:50	≤11:49
20–29						
Males	≥16:01	16:00–14:01	14:00–12:01	12:00–10:46	10:45–9:45	≤9:44
Females	≥19:01	18:31–19:00	15:55–18:30	13:31–15:54	12:30–13:30	≤12:29
30–39						
Males	≥16:31	16:30–14:44	14:45–12:31	12:30–11:01	11:00–10:00	≤9:59
Females	≥19:31	19:01–10:30	16:31–19:00	14:31–16:30	13:00–14:30	≤12:59
Males	≥17:31	17:30–15:36	15:35–13:01	13:00–11:31	11:30–10:30	≤10:29
Females	≥20:01	20:00–19:31	19:30–17:31	17:30–15:56	15:55–13:45	≤13:44
50–59						
Males	≥19:01	19:00–17:01	17:00–14:31	14:30–12:31	12:30–11:00	≤10:59
Females	≥20:31	20:30–20:01	20:00–19:01	19:00–16:31	16:30–14:30	≤14:29
60+						
Males	≥20:01	20:00–19:01	19:00–16:16	16:15–14:00	13:59–11:15	≤11:14
Females	≥21:01	21:31–21:00	20:30–19:31	19:30–17:30	17:30–16:30	≤16:29

Queen's College step test

Step tests are useful in assessing cardiorespiratory fitness because they can be administered to individuals or large groups of people without requiring expensive equipment or highly trained personnel. Like most step tests, the Queen's College step test uses recovery heart rate to assess aerobic fitness (McArdle et al, 1972).

The test is conducted in a single 3-minute period and requires a 41.3 cm (16.25 in) step or platform (which is the same height as many gymnasium bleacher seats). To produce an accurate, repeatable test, a metronome should be set to 88 beats per minute for females or 96 beats per minute for males. These rates will ensure that females perform 22 steps per minute whilst males perform 24 steps per minute if the following four-step cycle is followed: on count 1, step up on to the step with one foot; on count 2, step up with the opposite foot, fully extending both legs and the back; on count 3, return the first foot to the floor; and, on count 4, return the second foot to the floor.

At the end of the test, the participant remains standing and heart rate is recorded for 15 seconds beginning precisely 5 seconds after the 3-min stepping period has ended. Convert heart rate to beats per minute by multiplying by 4 and use the following prediction equations to estimate VO_2max (ml·kg-1·min-1): males = 111.33 – (0.42 x heart rate); females = 65.81 – (0.1847 x heart rate).

The predicted VO_2max scores can be used to identify fitness categories using the same tables as the Balke treadmill test. Beware, however, that the error associated with this method is 16% of the actual VO_2max.

The multistage fitness test

Leger and Lambert (1982) first developed a 20-metre shuttle run for the prediction of VO_2max. The 'bleep test' is now recognised as one of the most popular and valid tests of aerobic fitness in individuals or groups. The test should be performed on a dry, firm and flat surface with sufficient space for the 20-metre course and sufficient space for deceleration at each end (around 5–10 metres). During the test, participants move between markers whilst the bleep intervals become progressively shorter. Performance and interpretation of the test require a CD and normative data that are available on-line: www.defence.gov.au/army/hq8bde/jobs/fitness.htm.

Table of Predicted Maximum Oxygen Uptake Values for the Multistage Fitness Test. Department of Physical Education and Sports Science, Loughborough University, 1987.

Level	Shuttle	Predicted VO_2max	Level	Shuttle	Predicted VO_2max
4	2	26.8	14	2	61.1
4	4	27.6	14	4	61.7
4	6	28.3	14	6	62.2
4	9	29.5	14	8	62.7
			14	10	63.2
5	2	30.2	14	13	64.0
5	4	31.0			
5	6	31.8	15	2	64.6
5	9	32.9	15	4	65.1
			15	6	65.6
6	2	33.6	15	8	66.2
6	4	34.3	15	10	66.7
6	6	35.0	15	13	67.5
6	8	35.7			
6	10	36.4	16	2	68.0
			16	4	68.5
7	2	37.1	16	6	69.0
7	4	37.8	16	8	69.5
7	6	38.5	16	10	69.9
7	8	39.2	16	12	70.5
7	10	39.9	16	14	70.9
8	2	40.5	17	2	71.4
8	4	41.1	17	4	71.9
8	6	41.8	17	6	72.4
8	8	42.4	17	8	72.9
8	11	43.3	17	10	73.4
			17	12	73.9
9	2	43.9	17	14	74.4
9	4	44.5			
9	6	45.2	18	2	74.8
9	8	45.8	18	4	75.3
9	11	46.8	18	6	75.8
			18	8	76.2
10	2	47.4	18	10	76.7
10	4	48.0	18	12	77.2
10	6	48.7	18	15	77.9

Level	Shuttle	Predicted VO_2max		Level	Shuttle	Predicted VO_2max
10	8	49.3				
10	11	50.2		19	2	78.3
				19	4	78.6
11	2	50.8		19	6	79.2
11	4	51.4		19	8	79.7
11	6	51.9		19	10	80.2
11	8	52.5		19	12	80.6
11	10	53.1		19	15	81.3
11	12	53.7				
				20	2	81.8
12	2	54.3		20	4	82.2
12	4	54.8		20	6	82.6
12	6	55.4		20	8	83.0
12	8	56.0		20	10	83.5
12	10	56.5		20	12	83.9
12	12	57.1		20	14	84.3
				20	16	84.8
13	2	57.6				
13	4	58.2		21	2	85.2
13	6	58.7		21	4	85.6
13	8	59.3		21	6	86.1
13	10	59.8		21	8	86.5
13	13	60.6		21	10	86.9
				21	12	87.4
				21	14	87.8
				21	16	88.2

Velocity at VO_2max (vVO_2max):

This concept is based on the work performed by the highly respected French researcher Veronique Billat (1999). She advocates the importance of something called vVO_2 max which is the exercise velocity which causes your body to utilise oxygen at its highest possible rate. This has been shown to be a better predictor of ability and performance than VO_2max itself, as it encompasses elements of movement economy and efficiency - or how well the individual moves without wasting effort and oxygen on unnecessary movement. Training at an intensity equivalent to vVO_2 max has been shown to not only increase this variable, but also the ability to tolerate the fatiguing effects of lactic acid and movement economy, both of which are key features in enhanced performance. The next question, therefore, is how to calculate vVO_2max and how to use this in programme design. It should be emphasised that this is a test for intermediate to advanced clients who are clear of any risk factors and who are well motivated.

Determining vVO_2max is relatively easy to do. The activity mode chosen obviously depends on the client's sport and / or chosen activity. The rowing ergometer will be used in this example. After performing an appropriate warm up, the timer on the ergometer should be set to 6 minutes and the display to indicate distance travelled in metres. It is then a simple matter of working as hard as possible for this 6 minute time trial. It is tough and if the client is not used to pacing himself or herself over this duration they may want to have a few attempts to fully optimise performance.
Once the client has completed a good 6 minute effort, the following calculation should be done. Divide the distance travelled by 6 (metres per minute). For example, if the client rowed 1700 metres in 6 minutes this would be 1700/6 = 283.2. This is the vVO_2max in metres per minute. The test should also produce a maximum heart rate for the client as well. Based on the above result exercise intensity can be prescribed. For example: 50% of 283.2 = 141.6 metres per minute.

Muscular strength and endurance tests

Maximum muscle strength (low speed strength):

- hand grip dynamometer
- 1RM protocol

Hand grip dynamometer:

- adjust the gripping mechanism so that the second joint of the fingers fits snugly under the handle. The dynamometer should be gripped between the fingers and the heel of the hand
- the hand being tested should be held out in front of the body, free from contact with the body
- the client should be given two or three attempts on each hand with the highest reading from each hand recorded

One of the major drawbacks in using this test to assess strength is that it is only measuring a small select group of muscles.

One repetition maximum (1RM) protocol:

Dynamic strength is usually measured as the 1RM, which is the maximum weight that can be lifted for one complete repetition of that movement with perfect technique (Heyward, 2002). After familiarising themselves with the equipment, they are given several chances to achieve a maximal repetition with the resistance being increased incrementally with each trial. A maximum movement is hopefully attained within five trials so that fatigue does not become a confounding factor (Harman, Garhammer and Pandorf, 2000).

1RM testing protocol (adapted from Earle, 1999):

- instruct the athlete to warm-up with a light resistance that easily allows 5-10 reps
- provide a 1-minute rest period
- estimate a warm up load that will allow the client to complete 3-5 reps by adding:

    - 4-9 kg or 5-10% for upper body exercise
    - 14-18 kg or 10-20% for lower body exercise

- provide a 2-minute rest period
- estimate a conservative, near maximum load that will allow the client to complete 2-3 reps by adding the same increments as before
- provide a 2-4 minute rest period
- make a load increase using the same increments as before

- instruct the client to attempt a 1RM
- if successful allow a 2-4 minute rest period, then go estimate a new load
- if unsuccessful allow a 2-4 minute rest period, then decrease the load by subtracting:

    - 4-9 kg or 5-10% for upper body exercise
    - 14-18 kg or 10-20% for lower-body exercise

Continue increasing or decreasing the load until the client achieves a 1RM with good technique. The weight obtained as 1RM for upper and lower body can then be used as guidance for planning exercise loads and intensity.

Estimated strength test (taken from Sandler, 2005):

The estimated strength test is an alternative to the 1RM test; therefore, suitable for clients who should not be taken to maximum. These tests rely on a formula to predict maximum strength. Select one exercise for the upper body and one for the lower body. As with the 1RM test a suitable warm-up using a light weight for 5 to 10 reps should be performed. Follow the warm-up with a two minute rest then select a weight that failure is reached anywhere between 2 and 10 reps. The following formulae can be used to predict maximum strength:

- upper body rep max predictor:

$$\text{weight used for reps} \times \frac{1}{(1 - [\text{reps made} \times .025])}$$

- lower body rep max predictor:

$$\text{weight used for reps} \times \frac{1}{(1 - [\text{reps made} \times .035])}$$

Back extensors test (taken from McGill, 2002):

This test does not have a set of normative values, but simply provides a reference point for after the first test to compare future performance to.

- the client lies with the upper body extended over the end of a table or bench, hips, knees and pelvis secured
- the arms are held across the chest with the hands resting on the opposite shoulders
- the client is timed for their ability to maintain a level position
- the test is stopped once the client cannot hold a fixed horizontal position

Sit up test:

This test does not have a set of normative values, but simply provides a reference point for after the first test to compare future performance to.

- the client lies on their back with soles of the feet on the floor and knees at 90 degrees
- whilst keeping feet on the floor and hands held across the chest on opposite shoulders client should lift their body off the floor and sit up into an upright position
- client should return back to the floor with scapula in contact before completing each successive repetition
- the goal is to complete as many full repetitions in one minute

Power tests

Vertical jump test

Vertical jump tests can be performed in two distinct ways, the squat jump (SJ) and the countermovement jump (CMJ). Both assess the ability of the musculature of the hips, thighs and lower leg to propel the individual vertically into the air, but the CMJ utilises the elasticity in muscles and the stretch-shortening cycle whereas the SJ does not. If the trainer wishes to perform just one variant of the vertical jump test then the CMJ is probably more appropriate as it more closely replicates the way the body loads then unloads in function.

Countermovement jump (CMJ)

Equipment required:

- a smooth wall with a ceiling higher than the jumper can reach
- a flat floor with good traction
- chalk of a different colour than the wall
- measuring tape or ruler

Procedure:

- the client rubs chalk on the fingertips of their dominant hand
- the client stands side on to the wall with the shoulder of their dominant hand about 15cm from the wall
- with their feet flat on the floor the client reaches as high as they can and makes a chalk mark on the wall
- the client then performs a maximal countermovement jump. The countermovement requires the client to rapidly flex the hips and knees, bring the torso forward and down and swing the arms behind the body. This is the eccentric loading phase of the stretch-shortening cycle
- the concentric phase of the jump should instantly follow the eccentric loading phase. The client rapidly extends both hips and knees while simultaneously swinging the arms upward
- at the apex of the jump the client should make a second chalk mark with their fingertips
- the trainer then measures the vertical distance between the two chalk marks with the tape measure or ruler
- the best of three trials is recorded and taken as the client's test score

Normative table for vertical jump performance (CMJ)		
Performance % rank	**Female height (cm)**	**Male height (cm)**
91-100 World class	76-81	86-91
81-90	71-75	81-85
71-80	66-70	76-80
61-70	60-65	71-75
51-60	55-59	66-70
41-50	50-54	60-65
31-40	45-59	55-59
21-30	40-44	50-54
11-20	35-39	45-49
1-10	<35	<45

Adapted from Chu (1996)

Note that the normative table above is derived from data obtained from competitive athletes. Inappropriate use of this type of table could be very demotivating for the average client, as they are more likely to rank within a very lower percentile. Trainers are advised to exercise caution when comparing clients to normative tables of any kind. Test scores are more appropriately used to monitor a client's progress against their own previous performances.

This table shows average vertical jump performances obtained from a variety of population groups.

Vertical jump performance for various populations (CMJ)	
Population group	**Vertical jump height (cm)**
18-34 year old males	41
Recreational male college athletes	61
Competitive male college athletes	64-65
18-34 year old females	20
Recreational female college athletes	38-39
Competitive female college athletes	41-47

Adapted from Newton (2002)

The vertical jump tests are particularly useful for clients that participate in sports or activities that require powerful vertical leaping for successful performance. Examples of such sports would be basketball, netball, volleyball, high jumping and certain positions in rugby.

Squat jump

The procedure for the squat jump is similar to the CMJ. The only difference is that the jump is initiated from an isometrically held, partial squat position. The trainer should ensure that there is no movement from the client for a period of 2 seconds once the partial squat position has been adopted. Measurement of the squat jump is recorded in the same way as for the CMJ.

Standing broad jump:

Like the vertical jump tests the standing broad jump can be performed almost anywhere with limited equipment.

Equipment required:

- flat surface with good traction
- tape measure
- straight line marked on the floor

Procedure:

- the client starts with their feet shoulder width apart, and their toes behind the line marked on the floor
- the client swings their arms behind the body and simultaneously initiates a countermovement from their knees and hips (performs a ¼ to ½ squat)
- the client swings their arms forward and extends knees and hips to leap explosively forward as far as possible
- the trainer marks the back heel of the client and measures the distance between this mark and the start line
- the best score of 2-3 trials is recorded

The trainer can also conduct a non-countermovement jump by instructing the client to adopt a static semi-squat position behind the starting line prior to the jump phase. This squat must be held statically for 2 seconds prior to the jump.

Normative table for standing broad jump performance (CMJ)		
Performance % rank	Female distance (m)	Male distance (m)
91-100 World class	2.94-3.15	3.40-3.75
81-90	2.80-2.94	3.10-3.39
71-80	2.65-2.79	2.95-3.09
61-70	2.50-2.64	2.80-2.94
51-60	2.35-2.49	2.65-2.79
41-50	2.20-2.34	2.50-2.64
31-40	2.05-2.19	2.35-2.49
21-30	1.90-2.04	2.20-2.34
11-20	1.75-1.89	2.05-2.19
1-10	1.60-1.74	1.90-2.04

Adapted from Chu (1996)

Range of motion tests

It is possible to assess the flexibility of individual muscles/muscle groups and their possible impact on joint motion. These assessments allow more focus in the identification of tight or shortened muscles so that subsequent flexibility work can be more specifically targeted to the needs of the individual (Woodruff, 2003). The assessments illustrated below can be used to achieve a useful overview of key musculature. The optimal joint ranges of motion given are taken from Kendall et al (1993).

Start

Finish

Ideal range 70-90°

Hamstring muscles:

- client lies in the supine position, arms by their side
- trainer places one hand underneath the client's lumbar vertebrae and the other on the leg being assessed
- trainer raises the leg into hip flexion, until the client starts to go into a posterior pelvic tilt
- this tilt will be felt as the spinous processes pressing onto the trainer's hand
- trainer assesses the angle at which this pelvic tilt occurs. Repeat on the other side and compare


Start


Finish

Ideal range 140° or heel to gluteals

Quadriceps:

- client lies in the prone position
- trainer places one or two hands on the client's lower leg (shin), leaving the foot relaxed and the knee on the floor
- trainer raises this lower leg into knee flexion, until the 'spongy' end of ROM is reached, or until the pelvis rotates anteriorly
- trainer assesses the angle at which this occurs. Repeat on the other side and compare


Start


Finish

Ideal range 125°

Iliopsoas:

- client lies in the supine position, arms by their side
- trainer places two hands on the client's 'non-assessed' lower leg (shin), leaving the foot relaxed
- trainer raises this lower leg into knee and hip flexion, and pushes the knee towards the chest
- the pelvis is taken into posterior pelvic tilt, so the client has a flat back and when the hip flexor becomes taught the 'assessed' knee starts to lift
- trainer assesses the angle at which this occurs. Repeat on the other side and compare


Start


Finish

Ideal range 45°

Adductor muscles:

- client lies in the supine position, arms slightly out to the side
- trainer places one hand on the client's 'non-assessed' or far side ASIS (anterior superior iliac spine)
- trainer places other hand on 'assessed' or near leg and pulls this towards them, taking the leg into hip abduction
- trainer feels for the point where the ASIS starts to move, indicating a pelvic lateral tilt and that the hip adductors have reached their end of ROM.
- trainer assesses the angle at which this occurs. Repeat on the other side and compare


Start


Finish

Ideal range 180°

Pectoralis major and latissimus dorsi:

- client lies in the supine position in a posterior pelvic tilt (flat back), with their arms resting above their head
- trainer takes hold of the client's wrists, and instructs the client to completely relax their arms
- trainer raises the arms into shoulder flexion, then allows the arms to gently fall into their passive end ROM
- tight pectoral muscles will try to pull the arms into adduction
- tight latissimus dorsi muscles will try to pull the arms into extension
- trainer assesses for shoulder extension and/or adduction on both sides

Start

Finish

Start

Finish

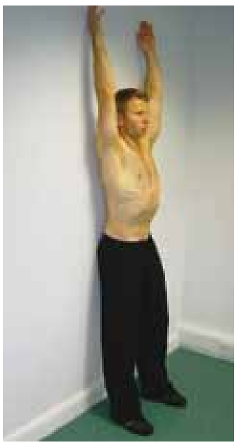
Ideal range 15-20°

Soleus and gastrocnemius:

- client lies in the supine position in a neutral spine, with their arms resting by their sides
- trainer takes hold of the sole of the client's foot, and asks client to relax their lower leg
- trainer takes the foot into (passive) ankle dorsiflexion, to assess gastrocnemius ROM (ideal of 15-20°)
- trainer can then assess active gastrocnemius ROM by getting the client to pull their toes back (dorsiflexion) unaided
- soleus flexibility can be assessed, by repeating the tests above, with one hand under the back of the knee, thus taking the knee in flexion
- assess the active and passive flexibility of both muscles and on both sides, compare with each other and the norms

Wall standing shoulder flexion:

- client stands against wall feet placed 4" away with back flat and arms by sides
- ask client to raise both arms above head as far as they can go without letting the lower back lift away from the wall
- stop test when low back lifts and observe the arm's distance from the wall
- a positive test, less than 180°, would be indicative of poor thoracic mobility and tightness in the shoulder medial rotators



Ideal range 180°

Appendix 3 - Example training log

Name:	Training phase:							Next phase:								
	Phase objective:							Weekly frequency:								
CV exercise	Time	Speed	Level	Intensity goal	Date											
1					Record time & intensity											
2																
3																
Resistance exercise	Sets/ reps	Weight	Rest	Intensity goal	Date											
1					Record sets, reps & weight											
2																
3																
4																
5																
6																
7																
8																
9																
Flexibility	Time	Phases	Intensity													
1					Tick when completed											
2																
3																
4																
5																
6																
7																
8																

Example periodised plan

Name:		Training objective:	Time frame:										
CV phases		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Taper													
Speed or power													
Transition													
Foundation													
Resistance phases		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Strength Power	1-3												
	4-5												
Hypertrophy	6-7												
	8-9												
	10-12												
Endurance	13-15												
	16-20												
Notes													

References

American College of Sports Medicine (1998). The recommended quantity and quality of exercise for developing and maintaining cardiorespiratory and muscular fitness, and flexibility in healthy adults. *Medicine and Science in Sports and Exercise,* **30**, 975-991

American College of Sports Medicine (2000). *ACSM's Guidelines for Exercise Testing and Prescription.* Lippincott Williams & Wilkins, Philadelphia

Baechle, et al (2000). *Essentials of Strength Training and Conditioning* (T. R. Baechle and R. W. Erle, ed.) pp. 393-425, Human Kinetics

Balke B and Ware R, (1959). A experimental study of physical fitness of Air Force personnel. *US Armed Forces Medical Journal*, **10**, 675-688

Billat et al, (1999). Interval training at VO_2 max: effects on aerobic performance and overtraining markers. *Medicine and Science in Sports and Exercise,* **31**, 156-163

Chu, D. (1996). *Explosive strength and power: complex training for maximum results.* Human Kinetics

Cooper, C.B. and Storer T. W. (2001). *Exercise testing and interpretation: a practical guide*. Cambridge University Press

Cotton, R.T. (1997). *ACE personal trainer manual.* ACE Publishing, 168-205

Daniels, J. (2001). *High Performance Sports Conditioning.* Human Kinetics, Champaign, Illinois, USA

Durnin J. and Wormersley J. (1974). Body fat assessed from total body density and its estimation from skinfold thickness: measurements on 481 men and women aged from 17 to 72 years. *British Journal of Nutrition,* **32**, 77-97

Hawley, J. and Burke, L. (1999). Peak Performance : T*raining and Nutritional Strategies for Sport.* Allen and Unwin, Australia

Fleck, S. and Kraemer, W. (1997). *Designing resistance training programs*. Human Kinetics

Franklin, B.A. (2000). *ACSM's Guidelines for exercise testing and prescription,* 6th Edition. Williams and Wilkins

Harmann E., Garhammer J. and Pandorf C. (2000). Administration, scoring and interpretation of selected tests. In: *Essentials of Strength Training and Conditioning.* TR Baechle and RW Earle, eds. Champaign: Human Kinetics, 2000. pp. 287-317.

Hartmann, J. and Tunnemann, H. (1995). *Fitness and strength training for all sports: theory, methods and programs.* Sports Book Publisher. Toronto

Hedrick, A. (1995). Training for hypertrophy. *Strength and conditioning Journal,* **17** (3), 22-29

Heyward, V.H. (1998). *Advanced Fitness Assessment and Exercise Prescription,* 3rd Edition. Human Kinetics

Heyward, V.H. (2002). *Advanced Fitness Assessment and Exercise Prescription,* 4th Edition. Human Kinetics

Hickson, et al. (1982) Reduced training duration effects on aerobic power, endurance, and cardiac growth. *Journal of Applied Physiology,* **53**, 225-9

Hickson, et al. (1985) Reduced training intensities and loss of aerobic power, endurance, and cardiac growth. J*ournal of Applied Physiology,* **58**, 492-9

Jalali, R. (2003). *Muscle breakdown: Is cortisol leading you down the catabolic pathway?* www.thinkmuscle.com/articles/jalali/cortisol.htm

Jones, A.M. and Doust J.H. (1996). A 1% treadmill grade most accurately reflects the energetic cost of outdoor running. *Journal of Sports Science*, **14**, 321-327

Kendall, F.P., McCreary, E.K. and Provance, P.G. (1993). *Muscles Testing and Function,* 4th Edition. Lippinncott Williams & Wilkins.

Knutten, H. and Komi, P. (1992). *Strength and Power in Sport.* Blackwell Science

Kordich, J.A.C. (2004). Client Consultation and Health Appraisal. In: *Essentials of Personal Training*

Kraemer, W. (2004). Roundtable discussion: periodisation of training part 1. *Strength and Conditioning Journal*, **26** (1)

Leger L.A and Lambert J. (1982). A maximal multistage 20-m shuttle run test to predict VO_2 max. *European Journal of Applied Physiology and Occupational Physiology,* **49** (1), 1-12

McArdle et al. (1972). Reliability and interrelationships between maximal oxygen intake, physical work capacity and step-test scores in college women. *Medicine and Science in Sports and Exercise*, **4**, 182-6

McArdle, W., Katch, F. and Katch, V. (2001). Exercise physiology: *Energy, nutrition and human performance*, 5th Ed. Lippincott, Williams & Wilkins

McGill, S. (2002). *Low back disorders: evidence based prevention and rehabilitation.* Human Kinetics

NIH (2003). The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC 7). *Hypertension,* **42**,1206

Nelson et al. (2005). *Seasonal Patterns of Stress, Immune Function, and Disease.* Cambridge University Press

Newton, R. and Kraemer, W. (1994). Developing muscular power: Implications for a mixed methods training strategy. *Strength and Conditioning Journal*, **16**, 20-31

Newton, H. (2002). *Explosive Lifting for Sports*. Human Kinetics

O' Connor J. and Lages A. (2004). *Coaching with NLP*. Element

Poliquin, C. (2001) *Modern trends in strength training*. Charles poliquin.net

Pollock et al. (1976). A comparative analysis of four protocols for maximal treadmill stress testing. *American Heart Journal*, **92** (1), 39-46

Reeves, R. A. (1995). Does this patient have hypertension? How to measure blood pressure. *Journal of the American Medical Association*, **273**, 1211-1218

Roitman, J.L. (2001). *ACSM's Resource Manual for Guidelines for exercise Testing and Prescription,* 4th Edition. Williams and Wilkins

Robergs, R. and Roberts, S. (1997). *Exercise physiology: Exercise, performance and clinical applications.* Mosby

Sandler, D. (2005). *Sports Power*. Human Kinetics

Siff, M. (2003). *Supertraining.* Supertraining Institute, Denver

Sproston, K. and Primatesta, P. (2004). In a report from the Chief Medical Officer. At least five a week. Evidence on the impact of physical activity and its relationship to health. *Department of Health*

Stanford School of Medicine. (2004). Stanford study links obesity to hormonal changes from lack of sleep. Available from http://mednews.stanford.edu/releases/2004/December/mignot.htm, 27 November 2005

Van Itallie, T.B. (1988). *Topography of body fat: relationship to risk of cardiovascular and other diseases.* Anthropometric Standardization Reference Manual. Human Kinetics

Wathen, D., Baechle, T. and Earle, R. (2000). Training variation: *Periodisation, in Strength training and conditioning,* Baechle, T. & Earle, R. (Eds), Human Kinetics

Woodruff, D. (2002). *Postural and Phasic Muscles: Applications in Exercise Protocols,* http://www.ptonthenet.com

Zatsiorsky, V. (1995). *Science and Practice of Strength Training*. Human kinetics

Unit Four
Delivering Personal Training Sessions

Delivering Personal Training Sessions

Aim: to provide the learner with the knowledge and skill needed to design, manage and adapt a personal training programme with apparently healthy adults of all ages. This includes reference to 14-16 year olds, older adults, pre and post-natal and disabled clients.

Learning outcomes

At the end of this unit the learner will:

- understand how to instruct exercise during personal training sessions
- understand how to adapt exercise to meet client needs during personal training sessions
- understand how to review personal training sessions with clients
- be able to plan and prepare personal training sessions
- be able to prepare clients for personal training sessions
- be able to instruct and adapt planned exercises
- be able to bring exercise sessions to an end

Instructing and adapting exercise

The PT needs to develop their ability to instruct and adapt exercises to meet a client's needs beyond the capacity of the gym instructor. It is imperative that client's consider the service, skills and abilities of the PT and that they perceive value in the additional money they pay. Improving the quality of personal training delivery includes:

- better preparation for a fitness session
- better observation and communication skills
- skilled exercise adaptation, progression and regression
- constructive review and feedback

Session preparation

After a client has been through their initial consultation and appraisal the trainer will have spent some time in preparation for the first fitness session. The client's objectives, health, current fitness and lifestyle will all dictate what the exercise programme will be like. The programme whilst being specific to the client's needs should still cover the key areas of physical development such as cardiovascular fitness, muscular fitness, flexibility, motor skills and core stability.

Areas of greater need agreed between the trainer and client should be reflected in the time, volume and intensity that such activities receive in the exercise programme. Exercise selection should also be appropriate to the client's capabilities and objectives. The gym equipment and resources available to the trainer may also largely determine the scope of exercise and training possible. This is where a skilled PT can really prove their worth by matching the needs of the client to specific exercises selected from the many thousands of possibilities.

It is important that the trainer has prepared both programme plans and the exercise environment prior to the beginning of an exercise session with a client. Preparing the exercise environment includes making sure exercise equipment is safe and available for use with proper alternatives in mind in case another gym user is utilising the equipment at the time it is needed. When these elements are in place the PT will be able to focus more on the client and adapting to their needs during the exercise session rather than having to write on the programme card, prepare and seek out equipment and other components of administrating a session.

When the client arrives

On arrival the client should be made to feel at ease whilst the PT familiarises them with the exercise and training environment identifying the areas and equipment that are going to be utilised in the session. In the early dialogue with the client the trainer should build rapport and gauge the client's state of readiness and preparation for the session, both mentally and physically. The client may express enthusiasm and excitement at the prospect of the gym session or may indicate that work or family life has thrown up barriers and distractions. These points must be taken into account when considering the physical demands that the planned session will put the client through and adjustments made if necessary.

The purpose of each exercise should be clearly explained whilst the trainer is guiding the client through the session plan clearly identifying how each exercise choice links to the objectives agreed upon between the trainer and client in the consultation.

Occasionally during the introduction to a new fitness programme it may become apparent that the client is uneasy about certain exercises that have been planned. It may be necessary to ‘tweak’ or change planned exercises before the trainer can begin the exercise session. Such last minute alterations to a planned programme are less likely if the original appraisal and consultation was thorough. However, if they do become necessary exercise alterations should be in line with the client’s goals and preferences. These changes should be recorded in the client’s training log and in the PT’s notes.

Prior to beginning the main session routine it is imperative that a client fully understands the importance of taking adequate time to warm up. The PT should ensure that the warm up planned for each session varies in line with what the client is being asked to do within the main session.

Instructional skills

First and foremost a PT needs to provide instructions to the client regarding exercise that are clear, technically correct and take into account safety at all times. Greater detail on specific exercise techniques can be found in the chapters that follow. Good coaching skills are an important part of helping client’s to develop sound exercise technique. The following list identifies the skills that may contribute to being a successful exercise coach:

- clear, concise teaching points
- stress positive exercise technique
- avoid teaching common techniques errors
- be observant, praise good technique and reinforce
- adapt teaching style to suit the client
- ease back as form improves to allow independence
- listen to and understand client’s feedback

The amount of short term information that a client is likely to retain when a new exercise is being taught is in many cases going to be minimal. This is not suggesting that any individual is not intelligent, but that learning new exercises and skills can be daunting. The PT must be mindful of this and simplify their instructions into 2 or 3 key exercise techniques points that can be easily grasped by the client.

As the client becomes more proficient in following the key points, then the trainer may wish to pick up on some of the more intricate finer details needed to master an exercise. It is vital that a trainer teaches the client what they should be doing rather than highlighting what they are doing wrong and telling them not to do it.

Correcting exercise form should be timed at appropriate points. Before the exercise begins and in between sets are obvious points at which instruction may be offered. Correction during exercise can be beneficial if done in an efficient and focused manner. The trainer's job is to provide simple, efficient instruction and to prioritise what matters most and is likely to make the most significant difference. Too much correction during exercise will likely create confusion.

The PT can enhance their instructional skills through the use of both verbal and non-verbal communication skills. When both skills are combined efficiently the trainer will be capable of teaching sound exercise technique in less time and with better understanding.

Dominant learning styles

It is important when instructing to be able to adapt the style of communication to fit with the client. It is generally accepted that there are three main styles of learning:

- visual
- auditory
- kinaesthetic

The trainer should emphasise the style that works best with the client. An observant trainer may have already determined the client's preferred learning style during the consultation and appraisal process. If this was not possible the trainer should try each different approach with a few exercises to determine which way the client seems to benefit the most.

The visual client

The visual client will most likely learn best through observing physical demonstrations or through pictures on exercise technique. The visual learner will also respond well to the use of eye contact, facial expression and gestures as they provide further stimulus to their preferred neurological pathway. Therefore, trainer needs to be within the client's field of vision during correction either directly or so they are reflected appropriately in the mirror.

The auditory client

The auditory individual will need things explained to them to be able to best process the information. The auditory learner will benefit from deeper verbal explanation of the exercise requirements with good variations in volume, tonality and pitch of voice. The visual demonstration should only be brief and exercise correction whilst they are performing will probably be best as verbal cues and instruction.

The kinaesthetic client

The kinaesthetic person will learn best by getting involved and actually performing the exercises and movements. The kinaesthetic person may benefit from involving them in some movement during the explanation, which should be kept brief and to the key points. The trainer may physically point out primary muscles used during the exercise on the client's body and create some movement in the joints and muscles to connect with their dominant learning style. The demonstration should also be brief and they may have the client mirror them as they demonstrate so that by the time they actually perform the exercise the client has learned the motion required already. The trainer will likely be able to use physical contact effectively with a kinaesthetic learner to correct technique, for example touching their low back with two fingers to remind them to maintain lumbar neutral during an exercise.

Whilst an individual may have a dominant learning style, it does not mean that they cannot learn from the other methods. The visual learner may, for example, still benefit from both auditory and kinaesthetic channels and so some attention should still be placed on these other methods of communication.

Other motivating factors

Instructing using the dominant learning style will prove motivating for many clients, but there are other aspects to motivation that can play a significant role. Finding the method of motivation that works best for each client can make the difference in achieving extra repetitions, weight or time during a training session. Motivating factors may include:

- volume of voice
- visual imagery
- reinforcing belief
- inverse motivation
- identifying key markers
- praise

Volume of voice

Not all clients will respond positively to a loud trainer, even if what is being said is well intentioned. It would be appropriate to ask the client their preference for motivation as some really get a buzz from an enthusiastic and encouraging trainer while others may prefer a quieter more consistent level of motivation that will not draw as much attention from others in the gym.

Visual imagery

Visually dominant clients will probably respond well to the use of imagery during a session to motivate them to reach new targets. It is common during group cycling classes for a good instructor to describe imaginary terrain, uphill or downhill gradients and the distance to various check points. This can help to break down a workout into easier to manage chunks. A PT can use similar techniques to motivate a client during certain exercises or movements by describing visual imagery to drive them to achieve or even to help with specific techniques or movements, particularly those that mimic common actions in daily life.

Reinforcing beliefs

Perhaps one of the most common ways to encourage a client who is finding an exercise difficult is through reinforcing their belief in their ability. This is usually done in the form of statements of belief such as ‘you can do it’, ‘you’re doing great’, or ‘keep it up’. However, once again not all clients respond best to this kind of motivation and occasionally some may even find it distracting.

Inverse motivation

Inverse motivation is a means of providing some form of opposition or competition to work against. This suits clients who enjoy having something to fight against. Inverse motivation should not be offensive, but provide some verbal drive for clients to focus on. Examples may include ‘this weight is better than you’ and ‘you were stronger than this last time’. The aim is not to demotivate the client, but to give them a push that they respond to. It is imperative that this type of motivation is only used with individuals who have a clear competitive drive. Clients who are relatively new and intimidated by the exercise environment will likely respond badly to such motivational techniques.

Identifying key markers

Identifying key marker during exercise such a distance covered, time to completion, number of repetitions and resistance achieved can provide valuable feedback to a client to spur them on. When a client is nearing the end of an exercise an indication of the proximity to completion can provide a positive burst toward accomplishing the objective.

Praise

One motivational tool that is virtually universal is praise. It is very satisfying to be told that a goal was reached, or a rewarding performance was delivered. Whilst worthy praise should never be withheld, it is also important not to offer praise flippantly for every completed set or exercises. The trainer needs to build a relationship with the client of performance expectation followed by reward and praise when it is clearly earned.

Adapting exercise

It is vital that a PT be observant to a client’s capabilities during an exercise session and adapts the exercises to suit their needs. There are several reasons why an exercise may need to be adjusted including:

- risks to client health
- size and shape of client
- intensity and variety of exercise
- movement and technical ability
- special population requirements

Risks to client health

It is important that exercise selection and adjustment take into consideration any health risks a client may present. Elevated blood pressure would, for example, of necessity dictate that overhead exercises should be minimised or avoided so that the shoulder press would be adapted to an upright row or lateral raise.

Size and shape of client

It is a necessary part of basic exercise programming to select and adapt exercises to allow individuals who are taller or shorter, slimmer or larger to be able to get the most out of an exercise machine or movement related activity. Differences in total load or lever length can have a significant impact on the physical challenge and neurological demand the exercise places upon the body.

Intensity and variety of exercise

The PT needs to know how to adapt the intensity to fit in with the objectives and the ability of a client. Too much or too little exercise intensity can have detrimental effects on the speed at which goals are achieved by inducing over or under training. Exercise variables that can vary the intensity experienced by the client include:

- sets and repetitions
- weight lifted
- rest between sets
- training systems utilised
- movement complexity
- speed of movement

These different variables can all be used to match the client's response to physical activity and push them just slightly beyond their comfort zone to bring about development.

Movement and technical ability

Restrictions in a client's movement capabilities can limit their ability to perform certain exercises. For example, a client with limited ankle dorsiflexion will find a squat exercise difficult to perform well and will tend to flex too much from the hips to compensate for their lack of dorsiflexion. Not only will this put their low back at increased risk, but will make the stimulus across the muscles involved imbalanced. Adapting the exercise by allowing the client to widen their stance will place less emphasis on the need for ankle dorsiflexion and give the client the 'room' to achieve a deeper squat. This means that squats can still be utilised in the exercise programme while ankle range of motion is improved upon.

Current exercise technique and the ability to develop technique will have a strong influence on the not only the choice of exercises, but the scope for adapting and progressing exercises.

Special population requirements

Exercise may need to be more specifically adapted to suit certain population groups. 14-16 year olds, older adults, pre and post-natal and disabled clients will all require a trainer to apply their knowledge of exercise intensity, selection and variety to ensure that the fitness programme meets their needs.

Monitoring progress

A well implemented system of collecting data on client performance, such as a training diary, will help immensely in being able to monitor and review and therefore, progress clients at the right time. However, within each individual exercise session the trainer needs to be able to determine progress made and whether or not a client is ready to move forward, stay where they are or be regressed. There a several methods of monitoring exercise performance in a gym environment:

- Rating of Perceived Exertion (RPE)
- heart rate
- observation
- performance markers

When RPE scores and peak heart rate are recorded during exercise the trainer can determine whether the desired intensities are being achieved and adjust any of the exercise variables necessary to raise these scores to the desired levels. Observation of client form and technique in conjunction with the strain or effort on the face, sweating and redness can provide reliable indicators of current performance especially when the trainer has become familiar with how an individual client looks at different levels of intensity. The trainer can also use performance markers such as the total number of repetitions in conjunction with the RPE on the final repetition to guide their judgement on whether progress is required. Other performance markers that can be utilised alongside intensity indicators are distance covered, weight or load, number of sets and repetitions or the time taken to completion.

Monitoring individual progress can be a little trickier when there is more than one individual being trained in a paired training session or in a group exercise setting. However, it is still important in these situations to be able to identify client performance indicators, such as those described above, to be able to optimise the workout and progress and regress as needed.

Session conclusion

At the end of a personal training session it is important that the trainer always makes time to cool the client down and carry out flexibility work where required. This will help to emphasise the importance of the 'wind down' part of any programme. The PT must be seen to value the cool down if they are to expect client compliance.

The cool down is beneficial for both the trainer and the client for a variety of reasons:

- controls the client's return to rest
- addresses client flexibility limitations
- enhances mental and physical relaxation
- provides feedback information about the session
- provides the client with feedback on their performance
- provides an opportunity to discuss other lifestyle factors
- reinforces teaching points and future goal achievement

A typical cool down should be adapted to match the demands of the session just completed. If the session emphasised legs, then little time need be spent on stretching out upper body muscles. Consideration also needs to be given on the intensity of the last few minutes of the main workout. If the session finished on some high intensity intervals the cool down may start at a moderate to vigorous level and diminish from there as the body is slowed to stop. If the session ended with some relatively simple core exercises it may be that the body has already begun to cool down and some basic, controlled mobility and stretching may suffice.

The cool down exercises may also be determined by a client's current health requirements. A pregnant client will only require minimal static stretching applied to muscle groups likely to shorten and tighten during the pre-natal state such as hip flexors, lumbar erectors and pectorals. An elderly client with arthritic knees may need to avoid static stretching of the quadriceps due to discomfort, but will likely benefit from controlled mobilisation of the joint at the end of a session.

The gym and the equipment used should always be left in a suitable condition for clients, members or trainers to use following a personal training session.

Review and reflect

A great skill the trainer needs to develop is the ability to provide honest and informative feedback on client performance in such a way as to maintain motivation and to assist in future performance. This feedback does not need to wait until re-appraisal or future consultation, but can be offered within exercise sessions. Immediate, constructive feedback will bring about better performance, lead to greater stimulus and ultimately quicker goal achievement.

It is relatively easy to provide honest and valuable feedback to a client when they have done well. The more difficult skill is to offer constructive and non-offensive criticism when client performance has been below par and has not reached the required intensity, skill or stimulus. Tonality of voice, perspective and the words chosen can all affect how the feedback will be received. The following two examples are used to contrast a poorly worded feedback statement and a positive and building feedback statement:

> *"You didn't manage to get the last 3 repetitions intended for that set. You lost neutral spine and your knee was buckling inwards towards the last few repetitions. Grit your teeth and let's make the next set count."*

> *"Great to see your effort during that set. Let's see if you can reach those last three repetitions in the next one. If you focus on keeping your chest lifted and your knee tracking in line with your toes you will perform better."*

Both statements provide feedback that is honest and accurate, but the first is more likely to reduce motivation and commitment to achieve. The second statement draws the focus away from the already completed poor performance and highlights the needs and expectations in the following set as well as the trainer's confidence in their ability to reach the objective.

The trainer can offer valuable feedback to a client at the end of each exercise session on how they are performing in relation to short, medium and long term objectives. It is important for the client to know where they are in relation to their objectives so that they can improve if needs be, maintain if they are on target or be satisfied if they are ahead of schedule. By being appropriately informed about future needs means the client can plan in advance and prepare themselves mentally for future expectations.

Following a personal training session, the trainer should reflect on the session. The trainer can review both client and trainer performance within the session and feedback received from the client regarding how they found the workout. A reflective practitioner will be able to look objectively at a session to identify successes and areas for development. Reflection upon a session may include:

- client achievement in relation to the session objectives
- use of motivational techniques and the effect on the client
- whether the instructional skills used match client needs

The trainer that honestly evaluates their personal training delivery and instruction will more effectively iron out inconsistencies in their teaching style and improve their ability to make their training even more 'personal'.

Resistance training exercises - sagittal plane

Exercise:	**Sagittal lunge with overhead medicine ball reach**
Primary muscles:	• quadriceps • hamstrings • gastrocnemius and soleus • deltoids and upper trapezius

Teaching points:	• stand in a comfortable stance with medicine ball held in two hands relaxed in front of hips • step forward about 2 feet with the left leg and lower the right knee toward the floor • simultaneously raise the medicine ball with straight arms above the head • maintain a neutral spine and keep the lead leg knee tracking over the foot • return to start position and repeat on opposite leg
Alternatives:	• regression: perform the overhead medicine ball reach whilst squatting on two legs • progression: keep the back foot off the floor and perform an overhead reach whilst doing a single leg squat

Exercise:	Sagittal squat with cable/band row
Primary muscles:	• quadriceps and gluteals • hamstrings • latissimus dorsi and posterior deltoids

Start

Finish

Teaching points:	• stand in a neutral stance facing cable column (or bands) • set the cable to ankle height • grip both handles and maintain neutral spine throughout • start by lowering into a squat with shoulders flexed and elbows extended • drive upwards into a standing position whilst pulling the elbows behind close to the sides of the body • control the descent back to the start position and repeat
Alternatives:	• regression: perform the same exercise without the squat by sitting on a stability ball • progression: perform the exercise with a single grip only and allow the body to naturally rotate at the bottom and top of the movement

Exercise: **Primary muscles:**	**Sagittal single leg medicine ball deadlift** • hamstrings • gluteals • lumbar erectors
 Start	 Finish
Teaching points:	• start in a split stance with the medicine ball held in front of chest • lift the back leg off the floor and flex at the hip whilst keeping the knee still in a soft position • simultaneously lower the medicine ball towards the ground • bend forward at the hip until the hamstring has reached end range and neutral spine is maintained • return to the start position and repeat
Alternatives:	• regression: keep one foot in contact with the floor at all times • progression: flex the shoulders so the medicine ball is over the head and in line with the body throughout the deadlift movement

Exercise:	**Overhead sagittal medicine ball reach**
Primary muscles:	• abdominals • lumbar erectors • deltoids • hip flexors

Start

Finish

Teaching points:	• start with a split stance reaching the medicine ball forwards by the front leg knee • maintain good spinal alignment in the forward position • shift body weight backwards onto the rear leg whilst simultaneously raising the medicine ball overhead • reach over and backwards as far as is comfortable extending the spine and holding the elbows in an extended position • return to the start position and repeat
Alternatives:	• regression: perform the same movement but shorten the lever length by holding the elbows at 90° throughout • progression: start in a neutral two footed stance and step backwards whilst raising outstretched arms and medicine ball overhead – alternate feet with each repetition

Resistance training exercises – frontal plane

Exercise:	**Frontal plane dumbbell lunge**
Primary muscles:	• quadriceps • hamstrings • gluteals • calf complex
	
Teaching points:	• stand upright holding a dumbbell in each hand • lunge directly to the side and land foot firmly on the floor • shift body weight and centre of gravity over lead leg whilst reaching a dumbbell either side of the knee • keep the feet facing forwards and the trail leg straight • control the decent, drive off the lead leg back to the start position and repeat on the same leg
Alternatives:	• regression: keep feet in contact with floor in a wide position and move into frontal lunge position without the ground impact • progression: perform a frontal lunge whilst alternating legs each repetition

Exercise:	Frontal overhead medicine ball lunge
Primary muscles:	• quadriceps • hamstrings and gluteals • gastrocnemius and soleus • deltoids
	
Teaching points:	• stand upright holding a medicine ball relaxed at hip height • lunge directly to the side and land foot firmly on the floor • shift body weight and centre of gravity over lead leg whilst raising the medicine ball directly overhead with arms straight • keep the feet facing forwards and the trail leg straight • control the descent, drive off the lead leg returning arms and legs back to the start position and repeat on the same leg
Alternatives:	• regression: raise the medicine ball in front of the body to shoulder height during the frontal lunge • progression: perform a frontal lunge with overhead raise whilst alternating legs each repetition

<table>
<tr><td>Exercise:

Primary muscles:</td><td>Frontal step up

• quadriceps
• hamstrings and gluteals
• gastrocnemius and soleus
• hip adductors and abductors</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td>Teaching points:</td><td>• stand beside a 12 inch step with both feet on the floor and a barbell across shoulders
• step directly up and to the side and land foot firmly on the far side of the step
• shift body weight and centre of gravity over lead leg whilst driving upwards off the ground
• land the trail leg on the near side of the step then immediately return it to the floor
• control the descent with the lead leg and return to the start position then repeat</td></tr>
<tr><td>Alternatives:</td><td>• regression: use a 6 inch step and keep lead foot in contact with the step at all times driving upwards and controlling decent
• progression: perform a frontal step up and travel to the other side of the step rather than return the same side switching legs at the top</td></tr>
</table>

Exercise: Primary muscles:	Single leg stability ball squat • quadriceps • hamstrings and gluteals • gastrocnemius and soleus


Start


Finish

Teaching points:	• stand on one leg with a stability ball placed between the lumbar spine and a wall • whilst holding the arms in front at shoulder height lower the body down into a squat position • keep the knee tracking in line with the foot and lower as far as is comfortable whilst maintaining neutral spine • drive upwards to the start position and repeat
Alternatives:	• regression: allow the trail leg to touch the floor for balance, but do not put body weight through it whilst performing the single leg squat • progression: hold the trail leg in front with the knee extended whilst holding light dumbbells to increase resistance during the single leg squat

Resistance training exercises – transverse plane

Exercise: Primary muscles:	**Transverse dumbbell lunge** • quadriceps • hamstrings and gluteals • gastrocnemius and soleus
	
Teaching points:	• stand upright holding a dumbbell in each hand • rotate the lead leg and lunge between 90° and 135° from the start position and land foot firmly on the floor • shift body weight and centre of gravity over lead leg whilst reaching a dumbbell either side of the knee • keep the trail leg foot fixed forwards in the start position and the knee straight • control the decent, drive off the lead leg rotating back to the start position and repeat on the same leg
Alternatives:	• regression: reduce the angle of feet to a maximum of 90° and perform transverse lunge whilst keeping both feet in contact with floor • progression: perform a transverse lunge whilst alternating legs each repetition

Exercise:	Stability ball single arm dumbbell press
Primary muscles:	• pectorals and deltoids • triceps brachii • gluteals and obliques

Start

Finish

Teaching points:	• lay back in a stability ball bridge position with ball between scapula and hips extended so the body is in line from knees to shoulders and feet shoulder width apart • hold a dumbbell in one arm extended above the body and place the other hand on the hips • lower the dumbbell while bringing the elbow out to the side and keeping the weight level with the chest • control the core and hips to maintain neutral whilst resisting the rotational force created by lowering the dumbbell • push the dumbbell upwards to the start position and repeat
Alternatives:	• regression: perform whilst holding the non-weighted arm out to the side to counter balance the weight and widen the feet position • progression: perform with feet together in a narrow position or with opposite leg raised off the floor

Exercise:	Medicine ball press up
Primary muscles:	• pectorals and deltoids • triceps brachii • abdominals

Start

Finish

Teaching points:	• start in a press up position with one hand on top of a medicine ball and feet held together • lower the body downwards whist maintaining as close to a neutral spine as possible • push upwards returning to the start position and repeat
Alternatives:	• regression: perform a ¾ medicine ball press up by placing the knees in contact with the floor • progression: perform with the opposite leg to the medicine ball raised off the floor 12 inches

Exercise:	**Squat with medicine ball reverse woodchop**
Primary muscles:	• quadriceps and gluteals • hamstrings • hip adductors and abductors • deltoids

Start

Finish

Teaching points:	• start standing in a neutral two footed stance holding a medicine ball • lower the body downwards into a squat whilst rotating the medicine ball over the left leg to the outside of the left hip • drive upwards out of the squat whilst simultaneously rotating the medicine ball upwards and over the right shoulder with the arms extended • control the descent and repeat
Alternatives:	• regression: perform seated on a stability ball • progression: perform in a split stance squat position

Power training exercises

Exercise:	**Squat jumps**
Primary muscles:	• quadriceps • hamstrings • gluteus maximus • calf complex

Start   Descent   Descent   Push-off

Teaching points:	• stand upright with dumbbells resting either side of body • drop quickly into a ¼ squat position (no pause) then explosively extend the hips to jump upwards • land softly with both feet, and chest over knees • hold and stabilise • return to the start position
Alternatives:	• regression: perform without actually leaving the floor, but driving upwards quickly and onto tips of toes • progression: perform the jumps with no stabilising rest between repetitions

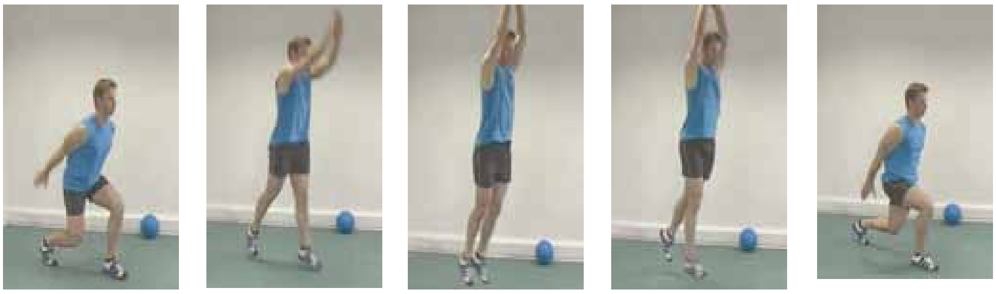
Exercise:	**Split squat jump**
Primary muscles:	• gluteus maximus • quadriceps • hamstrings • calf complex

Start

Descent

Push-off

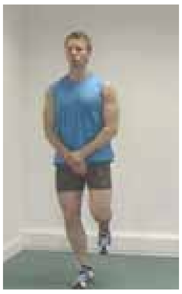
Teaching points:	• stand upright then adopt a split stance position with dumbbells resting either side of body • drop quickly into a ¼ split squat position (no pause) then explosively extend the hips to jump upwards • land softly with both feet in a split squat position (slightly flexed at the hips) • hold and stabilise • return to the start position
Alternatives:	• regression: perform a quick split squat without leaving the floor • progression: jump 18 inches to left and back in split squat position, then again to the right

Exercise:	**Jumping lunge**
Primary muscles:	• quadriceps • hamstrings • gluteus maximus • calf complex
 Start Push-off Alternate legs Land	
Teaching points:	• stand upright then adopt a split stance position • drop quickly into a ¼ split squat position (no pause) then quickly extend the hips to jump upwards using the arms to assist • at height of lunge change stance • land softly with both feet in a split squat position (slightly flexed at the hips) • hold and stabilise • return to the start position
Alternatives:	• regression: perform a jumping lunge with arms kept still by the sides • progression: perform the jumping lunge continuously without holding the movement on landing

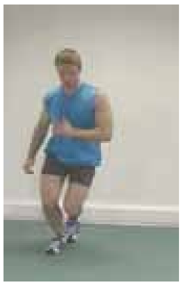
<table>
<tr><td>Exercise:

Primary muscles:</td><td>Frontal plane hop

• quadriceps
• hamstrings
• gluteus maximus
• abdominals
• calf complex</td></tr>
<tr><td colspan="2">







Start Push-off Land Push-off Land

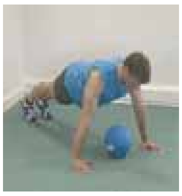
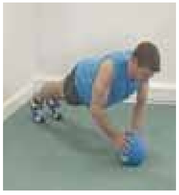
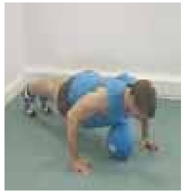
</td></tr>
<tr><td>Teaching points:</td><td>• stand upright on one leg
• drop quickly into a ¼ squat position (no pause) then extend the hips to hop laterally
• use arms to counter balance
• land softly in a ¼ squat position then stabilise
• repeat movement but this time hop laterally back to the start position</td></tr>
<tr><td>Alternatives:</td><td>• regression: perform the exercise on two legs – frontal jump
• progression: add footwork patterns – alternating legs and direction</td></tr>
</table>

<table>
<tr><td>Exercise:

Primary muscles:</td><td>Medicine ball Russian twist

• total body loading and unloading (rotational power)</td></tr>
<tr><td colspan="2">
Start Wind-up Load Unload</td></tr>
<tr><td>Teaching points:</td><td>• stand upright holding a medicine ball
• initiate by performing a countermovement (shifting weight onto left leg then onto the right)
• at the same time simultaneously rotate the trunk and arms to the left then the right
• to finish quickly rotate trunk and shift weight back to the left then release the medicine ball
• repeat to other side
• caution - this exercise must be performed away from other gym users
• use a partner, solid wall or outside in a field</td></tr>
<tr><td>Alternatives:</td><td>• regression: hold onto medicine ball throughout the exercise
• progression: sprint after the ball and repeat in the opposite direction</td></tr>
</table>

Exercise:	**Dumbbell push press**
Primary muscles:	• total body loading and unloading with emphasis on: • quadriceps • hamstrings • gluteus maximus • abdominals • gastrocnemius • trapezius • deltoids • triceps brachii
 Start	 Load  Push-off  Finish
Teaching points:	• stand in an upright position holding a pair of dumbbells in a shoulder press start position • drop quickly into a ¼ squat position (no pause) then explosively extend hips and knees to drive the body and dumbbells upwards to come onto the toes • at the same time extend the elbows to press the dumbbells upwards • neutral spine must be maintained throughout • lower dumbbells slowly to the start position
Alternatives:	• regression: reduce the load and perform a shoulder press • progression: perform with a single arm and split stance

Exercise:	Medicine ball push up press
Primary muscles:	• anterior deltoids • pectoralis major • triceps brachii • rectus abdominis
 Start	 Load  Push-off  Land and push-off  Finish
Teaching points:	• adopt a press up position • place a medicine ball in the midline of the body at shoulder level • perform a quick press-up counter movement • immediately explode by extending the elbows, pushing the body upwards • quickly move the hands to land softly on the medicine ball • immediately explode off the medicine ball by extending the elbows • to finish, land softly with both hands on the floor • repeat the process for the required number of repetitions
Alternatives:	• regression: clap hands instead of using a medicine ball • progression: place the medicine ball under one hand, perform an explosive press up whilst simultaneously rolling it over to the other hand, repeat

Exercise for motor skills

Exercise:	2 point box stance
Primary muscles:	• internal / external obliques, erector spinae, gluteals, deltoids

Start

Finish

Teaching points:	• start on hands and knees with hands directly under shoulders and knees directly under hips • extend one arm in line with body so arm is outstretched above the head • resist the pull of gravity on the side with the extended arm and maintain neutral alignment of the spine • extend the opposite hip to the extended arm bringing the leg directly behind and in line with the body • once again resist the pull of gravity and maintain a steady alignment • hold this position for 10 seconds then return to start position • repeat on the opposite side
Alternatives:	• regression: only lift the leg or only lift the arm if neutral cannot be maintained • progression: place a stability disc under one supporting hand or knee to increase demand

Exercise: Primary muscles:	**Stability ball twist** • internal / external obliques, erector spinae, gluteals

Start

Finish

Teaching points:	• start in a ball bridge position with the feet fixed on the ground, hips in line with the body, the ball rested between scapula and the head rested in neutral on the ball • hold the hands palms together directly above the body at arm's length • drive one shoulder round into the ball and rotate the torso to one side whilst maintaining hip position and bringing the arms round to the side • slowly control the return to the start position to regain neutral alignment • repeat on the opposite side
Alternatives:	• regression: instead of rotating the upper body, hold the bridge position whilst lifting one foot off the ground and extending the knee to create a rotational force from the hips • progression: use a medicine ball gripped in between hands to increase demand

Exercise:	**Single leg foot touches**
Primary muscles:	• quadriceps, gluteals, hamstrings, gastrocnemius, soleus
 Start	 Finish
Teaching points:	• stand on one foot with bar or rod placed across the shoulders • reach the opposite leg laterally to touch a point 18 inches away whilst flexing at the hip, knee and ankle on the stance leg • extend the hip, knee and ankle to return the stance leg to a straight position • repeat the same process maintaining the same stance leg whilst reaching the other leg posterior and laterally to touch a point 18 inches away • return to the start and repeat • alternate stance leg after each set
Alternatives:	• regression: perform a single leg isometric hold with leg opposite leg raised off the floor 6 inches in front • progression: change the direction of each foot touch to vary the challenge working around the points of a clock

Exercise:	Single leg transverse bends
Primary muscles:	• hamstrings, gluteals, gastrocnemius, soleus, erector spinae
 Option 1	 Option 2
Teaching points:	• stand on one leg • flexing from the hips reach down to the floor whilst keeping the knee soft but static and maintain a neutral spinal position • reach the back leg behind the stance leg drawing the hips in a posterior transverse motion • return to the start and repeat • option 2 is similar but the transverse motion is generated by reaching the opposite are from the stance leg across the body to the other side whilst flexing from the hips
Alternatives:	• regression: perform either position as an isometric single leg hold • progression: combining both motions to be performed as a single repetition will increase neural demand and work on the stance leg hip

Exercise: Primary muscles:	Single leg medicine ball woodchop • gluteals, internal and external obliques, deltoids
 Start	 Finish
Teaching points:	• begin by standing on one leg with the opposite leg flexed at the hip and knee to 90° • hold the med ball to the side of the stance leg hip in two hands with the torso rotated the same hip • whilst maintaining balance rotate the torso to the other side while raising the med ball above the opposite shoulder to the stance leg • The raised opposite side leg should be held in place throughout the repetitions • slowly control the return to the start position and repeat • change legs and repeat moving in the opposite direction
Alternatives:	• regression: touch the non-stance leg toes to the floor behind the body to reduce the balance demand if needed • progression: perform a single leg squat whilst lowering the med ball and drive out of the squat whilst raising the med ball

Exercise: Primary muscles:	Bosu squats • gluteals, quadriceps, hamstrings, gastrocnemius, soleus

Start

Finish

Teaching points:	• start by carefully placing one foot onto the Bosu at a time just inside the circular edge of the platform and finding a state of balance with the platform level • flex the shoulders bringing the arms out in front of the body to shoulder height to serve as a counter balance • flex at the hips, knees and ankles to lower the body into a squat position in a controlled manner • drive upwards extending the hips, knees and ankles to return to the start position, then repeat • try to maintain a level platform throughout the full movement
Alternatives:	• regression: turn the Bosu over so the flat platform is on the floor and stand on the round side to reduce the balance demand • progression: hold a med ball in front to increase the load

Core training exercises

Exercise:	**Cable woodchop**
Primary muscles:	• internal / external obliques – spinal rotation

Start

Finish

Teaching points:	• stand side on to cable column with feet shoulder width apart • position cable to top of column • shift weight onto leg nearest cable column and rotate trunk to clasp the cable handle with both hands • pivot opposite foot to allow for increased rotation • keeping arms straight and chest lifted, simultaneously shift weight over to opposite leg and rotate trunk around an upright axis • arms move down in a diagonal pattern ending just to the side of the opposite leg • pause briefly, then return to the start
Alternatives:	• regression: use a resistance band to perform woodchop without a frontal leg weight shift • progression: step and lunge out to side whilst rotating the torso

Exercise: **Primary muscles:**	**Reverse cable woodchop** • internal / external obliques – spinal rotation
  Start Finish	
Teaching points:	• stand side on to cable column with feet shoulder width apart • position cable at bottom of column • squat down, shifting weight onto the leg nearest the cable column and rotate trunk to clasp cable handle with both hands • keeping arms straight your chest lifted, simultaneously drive up through the hips and shift weight over to opposite leg, pivoting the foot to allow for increased rotation • rotate trunk around an upright axis as arms move up in a diagonal pattern with hands ending above head height • pause briefly, then return to the start
Alternatives:	• regression: use a resistance band to perform woodchop without a frontal leg weight shift • progression: step and lunge out to side whilst rotating the torso

<table>
<tr><td>Exercise:

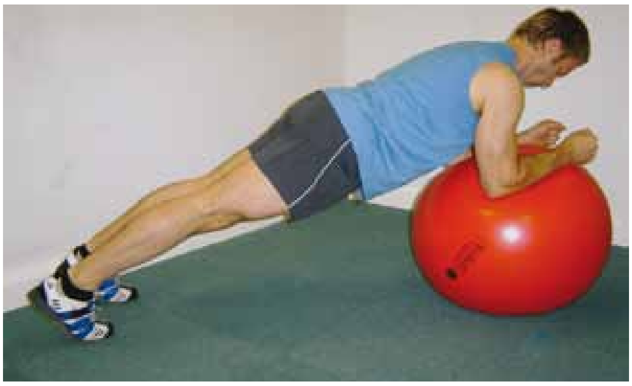
Primary muscles:</td><td>Standing cable Russian twist

• internal / external obliques – spinal rotation</td></tr>
<tr><td colspan="2"> 
Start Finish</td></tr>
<tr><td>Teaching points:</td><td>• stand side on to cable column with feet shoulder width apart
• position cable between shoulder and hip height
• Shifting weight onto the leg nearest the cable column, rotate trunk to clasp cable handle with both hands
• keeping arms straight, your chest lifted, simultaneously rotate through the hips and shift weight over to opposite leg, pivoting the foot to allow for increased rotation
• rotate trunk around an upright axis as arms move in a horizontal pattern with hands ending above head height
• pause briefly, then return to the start</td></tr>
<tr><td>Alternatives:</td><td>• regression: use a resistance band to perform woodchop without a frontal leg weight shift
• progression: step and lunge out to side whilst rotating the torso</td></tr>
</table>

<table>
<tr><td>Exercise:

Primary muscles:</td><td>Dead bug

• rectus abdominis, transversus abdominis, hip flexors</td></tr>
<tr><td colspan="2">
Start</td></tr>
<tr><td>Teaching points:</td><td>• adopt a supine position on an exercise mat
• start with the hips and shoulders flexed at 90°
• brace abdominal muscles to maintain a neutral spine then slowly extend one leg and flex opposite shoulder overhead
• pause, then return</td></tr>
<tr><td>Alternatives:</td><td>• regression: bend the knee to 90° during the lowering phase
• progression: hold a medicine ball during the movement</td></tr>
</table>

Exercise: Primary muscles:	**Stability ball abdominal plank** • rectus abdominis, transversus abdominis, hip flexors, stabilisers of the shoulder girdle
	
Teaching points:	• adopt a kneeling position with a ball arms length from body • place elbows and forearms on top of ball, then brace abdominal muscles and extend the knees and hips • maintain neutral spine throughout with elbows under shoulders • hold until form deteriorates
Alternatives:	• regression: perform the ball plank with knees on the floor • progression: roll the ball in small circles whilst holding plank • progression: lift one leg off the ground

Exercise: Primary muscles:	Prone twister • glutes rectus abdominis, transversus abdominis, hip flexors

Start

Finish

Teaching points:	• adopt a prone position over a ball with arms wrapped around the underside of the ball and chest touching the top of the ball • rest chin into ball, then brace abdominal muscles to maintain a neutral spine and extend hips and knee with feet shoulder width apart • gently roll to one side, decelerate that motion then return to the start position • repeat by rolling to opposite side
Alternatives:	• regression: perform the exercise with knees on the floor • progression: perform the exercise with feet on the ball and hands on floor in press up position

Assisted stretching

Stretch: lying gastrocnemius

- client lies supine on an exercise mat
- trainer adopts a stride stance
- trainer to rest client's heel on their hip, opposite leg rests with knee flexion
- trainer places one hand around the client's heel and the other on the ball of the foot
- trainer uses bodyweight to facilitate incremental increases in ankle dorsiflexion

Alternative stretch: lying gastrocnemius

- client lies supine on an exercise mat
- trainer adopts a kneeling stride stance
- foot is placed along the line of the trainers lower arm and palm of hand
- trainer's opposite arm supports the lower limb
- trainer facilitates incremental increases in ankle dorsiflexion

Stretch: lying hamstrings

- client lies supine on an exercise mat
- trainer adopts a kneeling stride stance
- client is asked to flex their stretching side hip and place their heel on the trainers' shoulder (a little knee flexion is required)
- by leaning forward the trainer facilitates incremental increases in hip flexion

Stretch: lying gluteals

- client lies supine on an exercise mat
- trainer adopts a kneeling stride stance
- client flexes their knee and hip
- trainer places one hand on the knee and the other under the client's heel
- trainer facilitates incremental increases in hip flexion

Alternative stretch: lying gluteals and piriformis

- client lies supine on an exercise mat
- client flexes both knees and hips, then places the stretching side lateral ankle just above the knee
- trainer adopts a kneeling stride stance
- trainer places one hand above the knee and one hand on the foot of the involved leg
- trainer facilitates incremental increases in hip flexion

Stretch: figure 4 – obliques, glute min & med

- client lies supine on an exercise mat
- flex a hip and knee to 90° and allow hip to fall over body
- on the involved side client places arm 90° at shoulder height
- trainer places one hand on flexed arm and the other on the knee of the involved leg
- trainer eases knee towards the floor to feel a stretch whilst keeping the arm down

Stretch: lying adductors	
	• client is sidelying on a exercise mat • downward arm is fully flexed with the head resting on it, the opposite arm is out in front for support • trainer adopts a kneeling stride stance • client abducts the top leg • trainer places one hand on the side of the clients pelvis, and the other on the inside of their knee • trainer facilitates incremental increases in hip abduction
Stretch: prone quadriceps	
	• client lies in a pronated position on an exercise mat • trainer adopts a kneeling stride stance • client flexes their knee keeping both knees together • trainer places one hand on the posterior superior iliac spine, and the other around the shin • trainer eases lower leg towards the buttock to feel a stretch
Stretch: sidelying rectus femoris	
	• client is sidelying on a exercise mat • inferior arm is fully flexed with the head resting on it, the opposite arm is out in front for support • trainer adopts a kneeling stride stance behind client • client lifts top leg and flexes knee • trainer places one hand on the side of the client's hip and the other on the inside of their knee • trainer facilitates incremental increases in knee flexion and hip extension to feel a stretch

Stretch: prone rectus femoris

- client lies in a pronated position on an exercise mat
- trainer adopts a kneeling stride stance
- client flexes their knee
- trainer places one hand on the posterior superior iliac spine, and the other around the lower leg
- by lifting the knee the trainer facilitates gradual hip extension

Stretch: obliques and latissimus dorsi

- client adopts a sidelying position on the ball with both arms positioned overhead
- clients' inferior knee supports the ball, the superior leg to stay straight with the foot fixed to the floor
- trainer standing posterior to the client places one hand on the pelvis and the other inferior to the shoulder joint
- trainer facilitates incremental increases in trunk lateral flexion

Stretch: seated pectoralis major

- client adopts a seated position on an exercise mat with legs crossed
- trainer places a ball behind the client to support their back
- trainer stands behind the ball and asks the client to abduct arms and flex elbows to 90°
- trainer takes hold of both arms on the anterior side of clients elbows and client takes hold of the trainers' elbow on the posterior side
- trainer facilitates incremental increases in horizontal extension to feel a stretch

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