Workbook

Level 2
Principles of Exercise, Fitness and Health
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Section 1: Physical activity and health

Learning outcomes

- To know the health benefits of physical activity.
- To understand the relationship between inactivity and the development of certain diseases.

Physical activity and health

The benefits of regular physical activity are wide-ranging. Someone undertaking regular physical activity will benefit from an improved level of fitness and find it easier to maintain a healthy weight. In addition their health will benefit as regular physical activity has a number of key health benefits including:

**Reduced risk of certain diseases:** people undertaking regular physical activity have a reduced risk of developing diseases including cancers, heart disease and diabetes.

**Improved bone health:** regular physical activity helps people build and maintain a healthy skeleton.

**Heart health:** physical activity places an increased demand upon the heart which makes it stronger, larger and more efficient.

**Posture:** the strengthening of the core muscles and key stabilising muscles means that people who take part in physical activity are likely to have a better posture than their inactive peers. The likelihood of improved posture increases further amongst those who follow a balanced resistance training programme.

**Functional strength:** regular physical activity helps people to maintain their functional strength making everyday activities easier.

**Independence in old age:** the fitter a person is the more likely they are to maintain their fitness throughout their senior years.

**Brain function and mental health:** regular physical activity has been shown to result in improved brain and nervous system function, better mental health, an improved ability to cope with stress and a lower risk of suffering from depression or anxiety disorder. Physical activity also helps prevent the development of dementia and Alzheimer’s disease in old age.

Physical activity and disease

Regular physical activity reduces a person’s risk of developing many conditions and will help people that already have certain conditions to manage their symptoms.

“I believe that evidence supports the conclusion that regular physical inactivity is one of the most important public health problems of the 21st century, and may even be the most important. My overriding concern is that the crucial importance of physical activity is undervalued and underappreciated by many individuals in public health and clinical medicine.”

*Professor Steven Blair, one of the eminent names in physical activity and disease research, The Cooper Institute, Dallas.*
Coronary heart disease
Coronary heart disease (CHD) is the most common cause of death in the United Kingdom (UK) and is responsible for one in five male deaths and one in seven female deaths. Whilst CHD risk is partly hereditary, lifestyle has a massive impact upon the risk of developing this disease. Those who make physical activity part of their lifestyle can reduce their risk of developing CHD.

Inactivity is an independent risk factor for CHD meaning that it increases a person’s risk regardless of other risk factors such as smoking and BMI.

Regular physical activity can help to lower blood pressure, improve cholesterol profile and maintain a healthy weight – these factors will help to lower CHD risk. High blood pressure is one of the most critical risk factors for CHD as it places excess strain on the heart and blood vessels. High cholesterol levels contribute to atherosclerosis which is the formation of ‘plaques’ in the arteries or the ‘furring’ of the arteries and is associated with CHD. When the coronary arteries become narrowed due to this ‘furring’ effect, the amount of blood that flows to the heart is reduced which can cause angina. If part of the plaque ruptures, the resulting blood clot can block the arteries leading to the heart and cause a heart attack.

Learning activity 1.1
How can physical activity help to lower a person’s risk of CHD?
1. 
2. 
3. 

Cancer
Regular physical activity is associated with a lower risk of certain cancers. In colon cancer inactivity is the greatest risk factor for development of the disease. The exact mechanism resulting in this reduced risk still remains unclear but it is known that people who maintain a healthy weight and body fat also have a lower risk of suffering from some other cancers, so physical activity is beneficial in this way too. Breast cancer risk, for example, is linked to body fat percentage and a woman’s risk of developing the most common type of breast cancer increases if she is carrying excess body fat.

Learning activity 1.2
Name two types of cancer linked to inactivity:
1. 
2. 

Learning activity 1.1
How can physical activity help to lower a person’s risk of CHD?
1. 
2. 
3. 

Type 2 diabetes

Type 2 diabetes develops mainly in people over 40 years of age and is also called ‘Non Insulin Dependent Diabetes Mellitus’ (NIDDM). If there is a family history of type 2 diabetes, a person is more at risk of developing this disease. Regular physical activity can, however, reduce this risk both directly at a cellular level and indirectly by preventing weight gain.

Type 2 diabetes develops due to the cells in the body becoming less sensitive or resistant to insulin or because the body is not producing adequate levels of insulin. Inactive people are more likely to develop insulin insensitivity and insulin resistance and thus have an increased risk of developing type 2 diabetes. One of the reasons for this is that visceral fat (fat inside the abdominal wall surrounding the internal organs) levels are generally higher in inactive people.

Hypertension

High blood pressure is more prevalent in people who are inactive than those who take part in regular physical activity. A ‘well-conditioned’ heart is stronger and more efficient. This means that it does not have to pump as hard in order to transport the blood around the body. This results in a lower pressure within the arteries (blood pressure). The blood vessels of people who are physically active remain more elastic and there is less likely to be a build-up of plaque in the arteries. This causes a lower resistance to blood flow, making it easier for blood to move around the system again meaning the heart doesn’t have to work as hard.

Learning activity 1.3

In the space below, using your own words, describe the link between physical activity and type 2 diabetes.

Learning activity 1.4

Next time you have the opportunity to use a hose pipe, try this:

Once you have turned on the tap and water is flowing evenly through the pipe place your hand in the stream of water and feel the pressure as it hits your hand. Now squeeze the end of the hose pipe to narrow the tube, and imagine the hose is an artery that has been narrowed due to plaque build-up. Place your hand in the stream of water now and you should feel the increase in pressure.

Obesity

Obesity develops when a person regularly consumes more calories than they need over a long period of time. Taking part in physical activity increases energy expenditure both during and after the session with the amount of energy expended being determined by the duration and intensity of the exercise. Being physically active is one of the most effective ways to prevent weight gain. Unfortunately, however, once someone has increased body fat above a healthy level, losing this purely by being active is incredibly difficult. Reducing energy intake is more effective for fat loss than physical activity alone, but the most effective approach is to use a combination of both.
Osteoporosis

Historically seen as a disease of old age, osteoporosis is now affecting younger people. This is believed to be because people are not placing adequate stress on their bones on a regular basis. Lifting heavy loads or engaging in activities that involve impact stimulates bone to adapt and become stronger. Conversely, inactivity does not stimulate bone activity and bones become weaker.

Osteoporosis literally means ‘porous bones’. It occurs when bones lose an excessive amount of their mineral content and leads to reduced bone mass and strength alongside an increased risk of fracture.

Weight-bearing activity stimulates the osteoblasts (the cells responsible for bone formation) to increase bone mineral density (BMD). BMD refers to the amount of minerals such as calcium contained in bones and it is used to estimate the ‘strength’ of a person’s bones and estimate the risk of developing osteoporosis. In order to maintain bone health, boost BMD and avoid osteoporosis, it is important to perform regular weight-bearing activities such as walking, jogging and resistance-based exercise. Undertaking these activities from a young age, when bone is growing and developing, means BMD will peak at a higher level when people reach their thirties. The higher peak BMD the lower the risk of developing osteoporosis later in life.

Learning activity 1.5

In the space below, using your own words, describe the link between physical activity and osteoporosis.

Summary

You should now know that physical activity is vital for good health as it can help to prevent and manage a range of medical conditions and diseases. In fact, physical inactivity is one of the biggest threats to a person’s health.

You should understand that adequate levels of the right type of physical activity can help to lower a person’s risk of:

- coronary heart disease
- type 2 diabetes
- some cancers
- obesity
- hypertension, and
- osteoporosis.

You should also be aware that physical activity can help people to maintain their functional strength and mental health which means that they are more likely to retain their independence in old age.
Section 2: The components of fitness

**Learning outcomes**
- To know the components of health-related fitness.
- To know the components of skill-related fitness.
- To be able to identify factors that affect health and skill-related fitness.

**Health-related fitness**
Fitness is often used as an all-encompassing term but it can be split into health-related fitness and skill-related fitness. Health-related fitness combines elements which affect general well-being. Certain sports and types of exercises place a larger demand on certain components of health-related fitness. Most people are advised, however, to aim to achieve a balanced level of performance in each component.

**Cardiovascular fitness**
Cardiovascular (CV) fitness is sometimes known as stamina or CV endurance and refers to a person’s ability to take part in and sustain continuous, submaximal exercise. Improved CV fitness will enhance a person’s quality of life and make everyday activities such as running for a bus or walking up stairs easier, as well as improving sports performance. CV fitness is the more common term but in reality this describes cardio-respiratory fitness as all of the above benefits rely upon the ability of the respiratory system to deliver oxygen to and remove carbon dioxide from the body. CV exercise improves the efficiency of the respiratory system.

**Muscular strength**
This refers to the maximal force that can be applied against a resistance and is measured by assessing the heaviest weight (one repetition maximum) that a person can lift, push or pull.

**Learning activity 2.1**
Identify four people you see as being ‘healthy’ and state why you view them in this way.

Use the space below to write brief bullet points to say why you see these people as being healthy. Your points may include physical characteristics (how they look), lifestyle choices (what they do, activities, work, diet) personality characteristics (energetic, happy, enthusiastic) as well as any illness history or lack of it.

Names and healthy characteristics:

Were there any common characteristics you identified?
Muscular endurance measures an individual’s ability to repeatedly perform a movement without fatigue.

Flexibility
This is a measure of a person’s range of movement (ROM) around their joints. It is particularly important that people maintain a decent level of flexibility as they age in order to ensure that their quality of life is not impaired. Flexibility is joint specific; that is, someone may have very flexible hips but stiff shoulders and tends to be sport specific; for example, it is of paramount importance in gymnastics but has less of an impact on rugby performance. Too much flexibility can be as damaging to joints as too little, especially if people do not have the strength to control their limbs through a full range of movement.

Body composition
Body composition refers to the amount of muscle, fat, bone, blood, water and so forth in the body. The two components which can be most influenced by physical activity are fat mass and muscle mass, so these are often measured and monitored. Excess fat mass is detrimental to a person’s health and will affect performance in sports.

Learning activity 2.2
What are the components of health-related fitness?

List them below and for each one give one benefit of maintaining this component of fitness in day-to-day life.

1.
2.
3.
4.
5.
Skill-related fitness

Skill-related fitness refers to the skills that people possess which will influence their technical performance in sport and exercise. A degree of skill-related fitness is essential for performing everyday tasks safely and with ease.

Speed

Speed is the ability to generate maximal velocity for any given movement. This could be moving an arm to catch a ball or moving the body from A to B. This skill is important in many sports and activities: even endurance athletes will attempt a ‘sprint-finish’ which requires speed.

Quickness

This refers to the ability to react and respond rapidly to a stimulus; for example, when people see an object coming towards them, can they react quickly enough to catch it or avoid it? Quickness involves training the brain as it must initiate a co-ordinated response to the stimulus.

Agility

Agility is the ability to change the direction and speed of movement quickly and efficiently in a co-ordinated fashion, without losing balance. This skill is important in most competitive sports; for example, football and skiing but less so in those such as weightlifting and sprinting.

Balance

Balance is all about not falling over! This skill can be static or dynamic and is best displayed in sports such as gymnastics and dance although it is also an important skill in other sports and it is vital that people maintain good balance as they age. In older age, good balance will help to prevent falls and potential bone injuries.

Co-ordination

Co-ordinated movements are more efficient and effective and will consequently improve performance. The ability to use different senses and parts of the body in a co-ordinated manner is best achieved through repetitive practice of good technique. All sports and activities require a certain level of co-ordination with some placing a higher demand on ‘hand-eye’ or ‘hand-foot’ co-ordination than others.

Power

Power is generated by performing movements that require explosive muscular strength. Power is sometimes known as speed-strength and is vital in some sports; for example, the take-off phase of the high jump and the kick of the ball in football. Power is also essential in old age as it is one of the most rapidly lost components of fitness with ageing. It is important that older adults are able to generate enough power to stand up from a sitting position and walk up stairs carrying objects in order to maintain independence.

Learning activity 2.3

Complete the table below by giving a use in daily life and a use in sport for each of the components of skill-related fitness:

<table>
<thead>
<tr>
<th>Motor-skill</th>
<th>Use in daily life</th>
<th>Use in sport</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quickness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agility</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Balance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Co-ordination</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Factors that affect fitness

There are many factors that affect a person’s fitness and their fitness potential, some of which can be influenced and some of which cannot be changed.

Genetics

Genetic background cannot be changed but it will play a huge part in a person’s fitness potential. Although elite athletes train very hard to get where they are, they are elite because of the genes that they were born with. This should not deter anyone from taking part in sport and physical activity as everyone can make fitness improvements. It must be recognised, however, that people have a ‘genetic ceiling’ to their fitness. It is important to appreciate this when setting goals with clients.

Age

As people age, many of the key components of fitness show a decline leading to a natural loss in fitness; for example, cardiac output and stroke volume decline affecting CV fitness potential and muscle mass is lost leading to a reduction in strength potential. Fitness can, however, be improved at any age and older people should strive to improve their fitness. It is worth stating that those who have a higher level of fitness to begin with are less likely to be affected by the natural decline caused by ageing.

Gender

Whether people are male or female will affect their fitness potential. In general men have an advantage over women when it comes to fitness as they tend to have larger hearts, lungs and blood volume meaning that they have a greater potential to develop CV fitness. Men also tend to have larger and stronger muscles, due to higher levels of anabolic hormones, making it easier to generate power as well as more efficient skeletal biomechanics. There are, however, many women who are much fitter than most men and there are components of fitness such as co-ordination and balance where women have an advantage over men. In general the anatomical and physiological differences between the genders explain the differences in performance of male and female elite athletes.

Current training status

Current training status obviously has a massive impact upon current level of fitness and also upon the fitness that can be achieved in the near future. The individual taking part in three gym sessions a week is likely to be much fitter than the sedentary individual who has just joined the gym.

Training history

Although fitness cannot be stored, the person who has been previously active and has previously achieved a certain level of fitness is likely to have an advantage over the person who has never been active. Previously active people will have a better idea about what they must do in order to become fitter but they may also have positive and / or negative associations with certain types of activity and exercise. It is important for people to base their activity upon the types of exercise that they enjoy and will maintain. An ex-army soldier, for example, may enjoy the sensation of intense exercise in a group environment such as circuits and get bored by yoga or training alone in a gym.

Nutritional status

One of the biggest factors affecting the ability to develop fitness is diet: do people eat the correct type and amount of food for their level and type of activity? If so, they will generally find that their activity will be beneficial and make them fitter. If not, it may be that the activity they undertake wears them out very quickly and could potentially make them ill, meaning that they will not continue. It is vital that people undertaking exercise and activity eat well, even if their goal is to lose weight.

Recovery / sleep

The amount and quality of sleep that people achieve can have a significant influence on their ability to develop their fitness. Poor sleep habits can be detrimental to fitness adaptations. It is important that people take time to recover properly from any exercise they undertake in order to ensure that optimal fitness adaptations can take place. Lack of recovery time can lead to a state called ‘over-reaching’ which can result in illness, an increased risk of injury and, if ignored over time, may develop into ‘over-training syndrome’. A properly planned exercise programme should ensure that adequate recovery time is allowed.
Medical history

It is important that anyone with a significant medical history (injury or illness) establishes that it is safe to take part in exercise or physical activity before doing so. Medical history needs to be factored into a programme when thinking about exercise type, intensity and duration. Medical history may affect the ability to improve fitness or take part in certain activities but it will not normally stop people exercising as long as appropriate adaptations are made.

Lifestyle

Lifestyle, which includes factors such as occupation and leisure pursuits, affects both current fitness levels and the ability to develop fitness. Most people spend the majority of their days at work and their job role will have a large influence on their fitness: consider how different the fitness levels of a plasterer and a bus driver are likely to be. The actual amount of time that people spend at work will also have an impact on their ability to take part in physical activity and consequently their fitness potential: the individual who works an 80 hour week will generally have less time to devote to activity than the 40 hour a week worker.

Outside of work, how people spend their leisure time also affects their fitness. If they prefer to spend their spare time in the pub watching football, they will probably be less fit than if it is spent walking the dog in the countryside.

Learning activity 2.4

Divide the factors that affect fitness into modifiable and non-modifiable factors.

<table>
<thead>
<tr>
<th>Modifiable factors</th>
<th>Non-modifiable factors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Learning activity 2.5

Consider the factors that would be required for someone to become an elite athlete. List those which you think are most important below:

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Summary

You should now know that fitness can be broken down into health-related fitness and skill-related fitness.

- Health-related fitness can be broken down into the following components:
  - cardiovascular fitness
  - muscular strength
  - muscular endurance
  - flexibility, and
  - body composition.

- Skill-related fitness can be broken down into:
  - speed
  - quickness
  - agility
  - balance
  - co-ordination, and
  - power.

You should understand the factors affecting people’s fitness levels and their fitness potential:

- genetics
- age
- gender
- current training status
- training history
- nutritional status
- recovery / sleep
- medical history, and
- lifestyle.
Learning objectives

- To know the cardiovascular and respiratory adaptations to endurance / aerobic training.
- To be able to identify the short and long-term effects of exercise on blood pressure.
- To understand the ‘blood pooling’ effect following exercise.
- To understand the effects of cardiovascular exercise on bones and joints including the significance of weight-bearing exercise.
- To understand the short and long-term effects of cardiovascular exercise on muscle.

Adaptations to cardiovascular training

Cardiovascular (CV) training which is well-programmed and executed results in a multitude of CV and respiratory system adaptations. These result in more efficient and effective CV and respiratory systems, which allow the individual to then perform the same level of exercise more comfortably or perform exercise at a higher intensity.

Decreased resting heart rate and submaximal heart rate

Regular CV training results in a decrease in resting heart rate (RHR). This is mainly due to the increase in stroke volume (SV) that occurs as a response to training. In addition to this, a person’s heart rate (HR) at any given submaximal exercise intensity will be lower following a period of CV training (see figure 3.1). The magnitude of this decrease can be up to around 12 to 15bpm (Seals and Chase 1989).

Figure 3.1 The effect of regular training on submaximal heart rate.

These changes occur because training results in increased stroke volume (SV), increased cardiac output (CO) and more efficient oxygen extraction from the blood. In other words, the fitter heart is able to pump more blood around the body with every beat and more oxygen can be removed from the blood per second by muscles and tissues, so the heart has to beat less often to meet oxygen demand at rest and at submaximal intensities.
Increased heart size

CV training results in an increase in muscle size and strength which is not limited to the skeletal muscles. The heart is primarily made up of muscle and it also undergoes hypertrophy through regular CV training, resulting in a more powerful, efficient heart. The trained heart will have a larger mass and left ventricular volume. Endurance trained people will have approximately a 25% larger heart volume than their untrained peers.

Increased stroke volume and cardiac output

Stroke volume (SV) is the amount of blood pumped from the heart with one beat. This is increased at rest and during submaximal exercise following a period of CV training. Increased SV contributes to the lower RHR and submaximal HR which results from CV training.

Cardiac output (CO) is the amount of blood pumped from the heart into the Aorta in one minute. CO is a product of the amount of blood pumped with each beat of the heart (SV) and the number of heart beats per minute (HR). This can be shown as an equation:

\[ \text{CO} = \text{SV} \times \text{HR} \]

The relationship between these three measures of cardiac activity is such that if HR increases and SV is constant, as would be the case if a person were warming up for exercise, then CO will increase in a linear relationship with heart rate. Following a cardiovascular training programme will eventually lead to an increase in SV as the size of the heart and amount of muscle mass increase. At rest the body of a trained individual needs no more oxygen than when it was untrained, so CO is the same. For this reason individuals who have followed a long-term cardiovascular training programme will find that their HR will decrease at rest and at any given submaximal workload. Training does, unsurprisingly, allow an individual to work at a higher maximal CO. A larger SV and equal maximal HR mean that the total amount of blood pumped in a minute is higher. In practical terms this translates to more oxygen being delivered to working muscles and a greater ability to produce energy using the aerobic energy system.

Improved blood profile

Plasma volume and red blood cell mass increase following CV training leading to an increase in total blood volume. This means that more oxygen can be carried in the blood as the increase in red blood cell mass increases haemoglobin concentration. The increased blood volume also contributes to the increase in SV.

Increased Minute Ventilation

Minute ventilation (VE) is the amount of air inhaled and exhaled in one minute and it is increased at maximal exercise intensity after a period of CV training. This is due to an increase in tidal volume (the amount of air inhaled and exhaled in one respiratory cycle) and respiratory rate (the number of breaths per minute). It is worth noting, however, that tidal volume and respiratory rate are not changed at rest following an exercise session.

At rest or for any given workload during submaximal exercise, respiratory rate decreases after a period of CV training. Little or no change in tidal volume is required to accommodate this decrease as oxygen is extracted more efficiently from the air in the lungs. These improvements in efficiency are due to adaptations in the structure of the lungs; such as, more capillaries growing around alveoli and changes to the blood; such as, more red blood cells to carry oxygen.
**Improved oxygen extraction from blood**

A period of CV training will increase the body’s ability to extract oxygen from the circulating blood. This occurs as a result of several adaptations including increased blood flow to the working muscles due to increased capillary density. There is also an increase in the amount of the oxygen-carrying compound myoglobin within the muscle cells. This allows the muscle cells to extract more oxygen from the blood as it flows past them in capillaries.

**Increased maximal oxygen uptake**

Maximal oxygen uptake (VO\textsubscript{2max}) refers to the maximal amount of oxygen that an individual can take up and use at sea level and it is a reliable measure of aerobic CV fitness. As would be expected, regular CV training will increase a person’s VO\textsubscript{2max} due to a number of adaptations already described, including an increase in the body’s ability to deliver oxygen to the working muscles and an increase in the muscles’ ability to extract oxygen from the bloodstream.

**Learning activity 3.1**

Use the diagram below to summarise the different adaptations to cardiovascular training:

![Adaptations to CV training diagram](image-url)
The effects of exercise on blood pressure

**BLOOD PRESSURE (BP)**

The force applied to the inside walls of blood vessels by the circulating blood. A blood pressure reading is made up of two numbers – systolic BP and diastolic BP. Systolic BP is the pressure recorded in the brachial artery during the contraction of the left ventricle of the heart. Diastolic BP is the pressure recorded in the brachial artery during the interval between left ventricular contractions as the heart relaxes and refills.

Exercise affects blood pressure but the actual effect will depend upon the type, the intensity and the duration of the exercise that is carried out. In the long term exercise is beneficial for blood pressure and it is, therefore, often recommended that people with hypertension (high blood pressure) begin a moderate intensity exercise programme if they are not already physically active.

**Short-term effects of cardiovascular exercise on blood pressure**

In the short term (meaning during an exercise session), CV exercise causes an increase in a person’s blood pressure. Any rhythmical activity which involves large muscle groups demands an increase in muscular blood flow, which results in a rapid rise in systolic BP during the first few minutes of the activity. Ideally, resting systolic BP will be less than 120mmHg in healthy adults but this will rise and level off at between 140mmHg and 160mmHg during steady-state exercise in healthy adults. Diastolic BP is ideally less than 80mmHg in healthy adults and they will experience relatively little change in diastolic BP during steady-state exercise.

If exercise intensity increases, as experienced in a graded-exercise test, systolic BP will continue to rise linearly with exercise intensity following the initial rapid rise – it is not uncommon for systolic BP to exceed 200mmHg during maximal exercise. Diastolic BP will, once again, remain relatively unchanged and it may even decline slightly, especially during longer sessions.

**Long-term effects of cardiovascular exercise on blood pressure**

Regular CV training can result in a decrease of approximately six to 10mmHg in both resting systolic and resting diastolic BP. The most notable decrease appears in systolic BP which is of particular importance to people with high BP (hypertension), as elevated systolic BP is thought to be more closely linked to CV disease than diastolic BP.

**Learning activity 3.2**

Using arrows, identify whether there is an increase or decrease in blood pressure in the following situations:

<table>
<thead>
<tr>
<th>Situation</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systolic BP during a submaximal run</td>
<td></td>
</tr>
<tr>
<td>Systolic BP when doing a set of squats</td>
<td></td>
</tr>
<tr>
<td>Systolic BP at rest after a 12 week CV training programme</td>
<td></td>
</tr>
<tr>
<td>Diastolic BP during a graded exercise test</td>
<td></td>
</tr>
<tr>
<td>Diastolic BP at rest after a 12 week cycling training programme</td>
<td></td>
</tr>
</tbody>
</table>
Blood pooling

**BLOOD POOLING**

The term ‘blood pooling’ is used to describe the accumulation of blood in the lower limbs if exercise is suddenly stopped without a cool down period.

During rhythmical exercise which involves the legs, the calf muscles act as ‘pumps’, squeezing blood in the veins back towards the heart. This is necessary as there is no pressure applied to blood in the veins from the heart to keep it moving. A sudden cessation in exercise means that this ‘muscle pump’ action stops abruptly and this can lead to the ‘pooling’ of blood in the legs as the heart will continue to beat at a faster than resting rate, forcing blood into the arteries for a few minutes after the exercise stops. This pooling means that the blood and any waste products contained within it collect in the calf muscles. This can occasionally lead to pain and swelling in the lower limbs. More commonly, due to the accumulation of blood in the lower limbs, individuals experience symptoms such as dizziness and fainting and sometimes a drop in blood pressure. To keep the blood being returned to the heart in the veins at the same rate as the blood being pumped out of the heart into the arteries, it is important to do a cool down until heart rate is near resting levels.

Learning activity 3.3

Read through the previous paragraph on blood pooling, then cover it up with a piece of paper and try to fill in the missing words in the paragraph below:

During rhythmical exercise which involves the legs, the calf muscles act as ‘……………’, squeezing blood in the …………….. back towards the heart. A sudden ……………….in exercise means that this ‘muscle pump’ action stops abruptly and this can lead to the ‘pooling’ of blood in the …………..as the heart will continue to beat at a ……………… than resting rate for a few minutes. This …………….. means that the blood and any waste products contained within it build up in the ……………. muscles which can lead to pain and swelling in the lower limbs. Due to the accumulation of blood in the lower limbs, individuals can also sometimes experience a drop in their blood pressure alongside symptoms such as …………….. and fainting.

Missing words: faster, dizziness, veins, legs, calf, pumps, cessation, pooling
Bone is a living tissue that is able to respond to certain types of exercise and become stronger through a process called remodelling. In fact, young people who take part in the right types of exercise will achieve greater peak bone mineral density (BMD) than those who do not, making them more resistant to fractures and less likely to develop osteoporosis later in life. It is also possible to prevent bone loss later in life by continuing to exercise regularly.

When it comes to bone health, however, not all types of cardiovascular (CV) exercise are created equal. For CV exercise to benefit bone health, it needs to be ‘weight-bearing’ and involve impact: this means that an individual must work against gravity. Examples of high impact, weight-bearing CV exercise include jogging, dancing and football. Swimming and cycling are not weight-bearing activities.

The table below provides a summary of the pros and cons associated with CV exercise and bone health.

Table 3.1 Pros and cons of CV exercise for bone health.

<table>
<thead>
<tr>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regular weight-bearing CV exercise can:</td>
<td>Regular weight-bearing CV exercise:</td>
</tr>
<tr>
<td>• boost peak BMD in young people</td>
<td>• tends to only benefit the lower body and lumbar spine</td>
</tr>
<tr>
<td>• help to prevent osteoporosis by slowing the rate of BMD loss in older people</td>
<td>• may result in over-use injuries in joints</td>
</tr>
<tr>
<td>• provide the stimulus needed to trigger increased bone strength, and</td>
<td>• increases the risk of soft tissue injuries, and</td>
</tr>
<tr>
<td>• enhance muscle, ligament and tendon strength thus strengthening the joints and improving stability.</td>
<td>• can lead to osteoarthritis due to the ‘wear and tear’ of cartilage within joints.</td>
</tr>
</tbody>
</table>

Learning activity 3.4

Circle the gym-based CV exercises you think are likely to improve bone health:

- Stationary bike
- Cross trainer
- Treadmill (running)
- Stepper
- Rowing machine
Effects of cardiovascular training on muscle

During cardiovascular (CV) exercise muscles are repeatedly contracting and relaxing. They produce a relatively low submaximal force each time they contract and there is a short rest period (relaxation) between each contraction. Muscle endurance, which is specific to the activity being performed, will be developed allowing long-term adaptations to take place within the muscles.

Learning activity 3.5

Use the space below to record, in your own words, your understanding of the effects of endurance training on muscle:

These long-term adaptations enable the muscle to perform the cycle of contraction and relaxation either for longer durations or at higher intensities for the same duration without fatigue. This applies to any CV exercise but consider the example shown in table 3.2 of what happens to the hamstrings muscle group in the short and long term when a person is jogging.

Table 3.2 The short and long-term effects of jogging on the hamstrings muscle group.

<table>
<thead>
<tr>
<th>Muscular action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Repeated contractions of the hamstring muscle group with relatively low force production over a long period of time.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Muscular action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Repeated contractions of the hamstring muscle group with relatively low force production over a long period of time.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Short-term effects:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metabolic activity within muscle fibres</td>
</tr>
<tr>
<td>Muscular blood flow</td>
</tr>
<tr>
<td>Enzyme activity</td>
</tr>
<tr>
<td>Rate of oxygen transport into muscle fibres</td>
</tr>
<tr>
<td>Rate of carbon dioxide into the blood stream</td>
</tr>
<tr>
<td>Transport of glucose and fatty acids into muscle fibres, and</td>
</tr>
<tr>
<td>Breakdown of glucose and fatty acids to produce energy.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Long-term adaptations:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size of type 1 fibres</td>
</tr>
<tr>
<td>Energy stores within muscles</td>
</tr>
<tr>
<td>Number of mitochondria</td>
</tr>
<tr>
<td>Mitochondrial size</td>
</tr>
<tr>
<td>Enzyme activity and quantity</td>
</tr>
<tr>
<td>Capillary density, and</td>
</tr>
<tr>
<td>Blood supply to muscles.</td>
</tr>
</tbody>
</table>
Summary

You should now know that a well-planned CV training programme will result in a range of physiological adaptations which lead to a ‘fitter’ CV system.

You should now understand that adaptations take place with CV training:

- decreased resting heart rate and submaximal heart rate
- increased heart size
- increased stroke volume and cardiac output
- improved blood profile
- increased minute ventilation
- improved oxygen extraction from blood, and
- increased maximal oxygen uptake.

You should now understand that blood pressure is influenced in the short and long term by exercise with the actual effect depending upon the type, intensity and duration of the exercise.

- In the short term, CV exercise causes an increase in systolic blood pressure with relatively little change in diastolic blood pressure.
- In the long term, regular CV training can result in a decrease in blood pressure which will benefit a person’s health.

You should know that a sudden cessation of exercise can result in blood pooling in the lower limbs. This can lead to dizziness, fainting, pain and swelling but is avoided by a proper cool down.

You should now understand how weight-bearing CV exercise can help to boost and / or preserve a person’s BMD and that higher BMD results in a reduced likelihood of osteoporosis in later life.

You should now know that regular CV training results in muscular adaptations specific to the activity performed which result in improved muscular endurance when performing that activity.
Learning outcomes

- To know the effects of resistance training on bones and joints including the significance of weight-bearing exercise.
- To understand the short and long-term effects of resistance training on muscle.
- To know how resistance training can improve posture
- To understand the phenomenon of delayed onset of muscle soreness (DOMS).
- To know the exercises or techniques likely to cause delayed onset muscle soreness.

Resistance training and bone health

RT is a type of weight-bearing exercise. If a load is placed through a bone that is significant enough to cause a deformation in the structure of that bone, it will stimulate the activity of osteoblast cells.

Osteoblasts build more bone and increase the bone mineral density, making the bone harder and stronger in order to cope with this load next time the bone has to deal with it. In a progressive RT programme, heavier and heavier loads are used, which causes the bone to continue to become stronger as more mineral is deposited.

There are other factors that determine the extent to which bone grows in this way, particularly nutrition and age. Figure 4.1 shows the normal changes in bone mass throughout life. It is particularly beneficial to perform resistance exercise as a young person when osteoblast activity is high, as there is greater potential for increasing bone mineral density than later in life. The higher the peak bone mass a person achieves the longer it will take the BMD to decrease to a point where the bone is considered ‘brittle’ and the lower that person’s risk will be of developing osteoporosis in old age.

Figure 4.1 Bone mass changes through the lifecycle.

RT still affects bone density later in life and acts to slow the rate of bone mineral loss. It may even increase bone mineral density although it could still be a case of too little too late if peak bone mass was low.
Although some forms of cardiovascular training have also been shown to have a positive impact on BMD at specific sites, RT has been shown to have a greater effect on a larger number of sites throughout the skeleton.

Although RT has an entirely positive effect on bone structure, the effects on joints can be mixed. In general a RT programme will have a positive effect on synovial joints. The regular and repeated movement through a full range of movement under load causes the cartilage to deform temporarily, this squeezes out the fluid within the cartilage and as the pressure is released, causes the cartilage to ‘suck’ up the synovial fluid from the synovial cavity like a sponge in water. This is the mechanism by which cartilage receives its nutrients and stays healthy so it makes sense that RT helps to nourish cartilage.

Ligaments hold bone to bone across joints. Like most connective tissue when stress is placed through them, ligaments are stimulated to thicken. They do this by adding more collagen protein fibres to their structure which are very strong. This leads to another benefit of RT for joints: improved passive stability.

Muscles are strengthened by RT, which also causes the muscle tone to increase, and this pulls on the tendons that connect the ends of the muscle to bone. If muscles all around a joint are strengthened in a relatively equal balance, the active stability of the joint will improve as the tendons across it get stronger and it is held taught by the muscles.

There is a risk, however, that if RT programmes are poorly balanced – by working muscles excessively on one side of a joint – the structure of the joint can change. Over time this can lead to poor posture and even permanent changes to the joint structure as bones remodel in adaptation to the forces pulling on them.

Uneven forces passing through a joint, often as a result of an injury or poor posture, can cause uneven pressure on cartilage covering one part of a joint surface. Unsafe exercise technique, inadequate arch support in footwear and imbalanced RT can contribute to these uneven forces. This pressure on one part of the cartilage can speed up the damage caused by wear and tear and lead to the development of cartilage tears or osteoarthritis in the joint. Joints most at risk of developing osteoarthritis are the hips, knees and ankles as they bear weight. Table 4.1 summarises the pros and cons of exercise for bones and joint health.

Table 4.1  Summary of pros and cons of resistance training for bones and joints.

<table>
<thead>
<tr>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>increased bone mineral density</td>
<td>cartilage damage can lead to osteoarthritis, and</td>
</tr>
<tr>
<td>reduced risk of developing osteoporosis</td>
<td>imbalanced programmes can lead to poor posture.</td>
</tr>
<tr>
<td>improved cartilage health</td>
<td></td>
</tr>
<tr>
<td>improved joint stability, and</td>
<td></td>
</tr>
<tr>
<td>improved joint alignment and posture.</td>
<td></td>
</tr>
</tbody>
</table>

Learning activity 4.1

Draw a diagram in the space below to show how bone mineral density (BMD) changes through life and annotate it to help you remember what effect exercise can have at each stage.
Effects of resistance training on muscle

Tables 4.2, 4.3 and 4.4 identify the changes that occur in muscle after a single RT session (short term) and with a regular RT programme that follows ACSM guidelines over a period of 12 weeks or longer (long term).

Muscular endurance training

Muscular endurance training involves performing RT exercises, often bodyweight and dumbbell exercises, with relatively light loads that cause muscle fatigue after 12 to 15 repetitions.

Muscular action

Repeated muscular action against a relatively low resistance.

| Muscular action
| Repeated muscular action against a relatively low resistance.
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Short-term effects:</strong></td>
</tr>
<tr>
<td>-&gt; metabolic activity within muscle fibres</td>
</tr>
<tr>
<td>-&gt; muscular blood flow</td>
</tr>
<tr>
<td>-&gt; aerobic enzyme activity</td>
</tr>
<tr>
<td>-&gt; rate of oxygen transport into muscle fibres</td>
</tr>
<tr>
<td>-&gt; rate of carbon dioxide into the blood stream</td>
</tr>
<tr>
<td>-&gt; transport of glucose and fatty acids into muscle fibres</td>
</tr>
<tr>
<td>-&gt; breakdown of glucose and fatty acids to produce energy, and</td>
</tr>
<tr>
<td>-&gt; rate of protein synthesis in type 1 fibres.</td>
</tr>
<tr>
<td><strong>Long-term adaptations:</strong></td>
</tr>
<tr>
<td>-&gt; size of type 1 fibres</td>
</tr>
<tr>
<td>-&gt; energy stores (glycogen, ATP and PCR) within muscles</td>
</tr>
<tr>
<td>-&gt; number of mitochondria</td>
</tr>
<tr>
<td>-&gt; mitochondrial size</td>
</tr>
<tr>
<td>-&gt; enzyme activity and quantity</td>
</tr>
<tr>
<td>-&gt; capillary density, and</td>
</tr>
<tr>
<td>-&gt; blood supply to muscles.</td>
</tr>
</tbody>
</table>

Hypertrophy training

Hypertrophy is the term used to describe an increase in cross sectional area (size) of muscle fibres. Type 2 fibres have a far greater ability to grow in this way and it is essential, therefore, to stimulate adaptation in as many fibres within the muscle as possible and use loads heavy enough to recruit the type 2 fibres. Hypertrophy training is performed with moderate to heavy loads that cause fatigue after eight to 12 repetitions and a high volume of training using a combination of multiple sets and exercises for each muscle group.

Table 4.3 Effect of hypertrophy training on the body.

| Muscular action
<table>
<thead>
<tr>
<th>Repeated muscular action against a moderate to heavy resistance.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Short-term effects:</strong></td>
</tr>
<tr>
<td>-&gt; metabolic activity within muscle fibres</td>
</tr>
<tr>
<td>-&gt; muscular blood flow</td>
</tr>
<tr>
<td>-&gt; transport of glucose into muscle fibres</td>
</tr>
<tr>
<td>-&gt; breakdown of glucose and glycogen</td>
</tr>
<tr>
<td>-&gt; enzyme activity</td>
</tr>
<tr>
<td>-&gt; transport of glucose and fatty acids into muscle to produce energy</td>
</tr>
<tr>
<td>-&gt; rate of protein synthesis</td>
</tr>
<tr>
<td>-&gt; Micro-trauma to myosin cross-bridges, and</td>
</tr>
<tr>
<td>-&gt; intramuscular lactic acid.</td>
</tr>
<tr>
<td><strong>Long-term adaptations:</strong></td>
</tr>
<tr>
<td>-&gt; size of type 1 and 2 fibres</td>
</tr>
<tr>
<td>-&gt; energy stores (glycogen, ATP and PCR) within muscles</td>
</tr>
<tr>
<td>-&gt; anaerobic enzyme activity and quantity to breakdown energy stores</td>
</tr>
<tr>
<td>-&gt; blood supply to muscles</td>
</tr>
<tr>
<td>-&gt; Optimal ↑ of muscle mass</td>
</tr>
<tr>
<td>-&gt; number of myosin cross-bridges</td>
</tr>
<tr>
<td>-&gt; Limited ↑ of maximal strength, and</td>
</tr>
<tr>
<td>-&gt; levels of intramuscular buffers to regulate acidity and resist fatigue.</td>
</tr>
</tbody>
</table>
Muscular strength training

Maximal strength can be expressed in terms of the one repetition maximum (1RM) of a resistance exercise. Muscular strength training involves the use of heavy loads to recruit as many fibres within a muscle as possible in a synchronised fashion in order to generate near maximal forces and stimulate the nervous and muscular systems to adapt.

The risk of musculoskeletal injury is high when lifting loads close to 1RM as, by definition, they are at the limits of their strength. Muscular strength training is, therefore, unadvisable for people who do not have training experience and excellent posture and lifting technique. Loads causing fatigue at one to five repetitions can be used in a periodised fashion but when introducing strength training to people loads that cause fatigue at six to eight repetitions are effective at increasing maximal strength with lower risk of musculoskeletal injury.

Table 4.4 Effects of strength training on the body.

<table>
<thead>
<tr>
<th>Muscular action</th>
<th>Short-term effects:</th>
<th>Long-term adaptations:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Repeated muscular action against a heavy resistance.</td>
<td></td>
<td>• size of type 1 and 2 fibres</td>
</tr>
<tr>
<td></td>
<td>• metabolic activity within muscle fibres</td>
<td>• energy stores (glycogen, ATP and PCr) within muscles</td>
</tr>
<tr>
<td></td>
<td>• muscular blood flow</td>
<td>• enzyme activity and quantity to breakdown energy stores</td>
</tr>
<tr>
<td></td>
<td>• transport of glucose into muscle fibres</td>
<td>• blood supply to muscles</td>
</tr>
<tr>
<td></td>
<td>• breakdown of glucose and glycogen</td>
<td>• optimal increase of muscle mass</td>
</tr>
<tr>
<td></td>
<td>• enzyme activity</td>
<td>• number of myosin cross-bridges</td>
</tr>
<tr>
<td></td>
<td>• transport of glucose and fatty acids into muscle fibres to produce energy</td>
<td>• maximal strength</td>
</tr>
<tr>
<td></td>
<td>• rate of protein synthesis</td>
<td>• levels of intramuscular buffers to regulate acidity, and</td>
</tr>
<tr>
<td></td>
<td>• micro-trauma to myosin cross-bridges</td>
<td>• improved neuromuscular communication.</td>
</tr>
<tr>
<td></td>
<td>• intramuscular lactic acid, and</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• neural fatigue.</td>
<td></td>
</tr>
</tbody>
</table>
The exercise, three sets of heavy leg curls, is performed with muscle fatigue reached at around six repetitions each set. Two minutes rest is taken between sets.

The hamstrings need only a low number of contractions to fatigue, recruiting many high force type 2 muscle fibres and causing a lot of microtrauma to the myosin cross bridges. The long recovery period between sets allows lactic acid to be buffered or removed from muscle fibres and the majority of PCr stores to re-form before the muscle needs to contract again.

In the short-term recovery period immediately after the session:
Microtrauma to myofilaments, particularly myosin. Repair begins immediately with increased rate of protein synthesis in the muscle, which then repairs the damage and adds additional cross bridges.
Depletion of creatine phosphate after the first few repetitions stimulates the need for an increased amount of PCr and more of the enzymes required to break it down.
A build-up of lactic acid stimulates a need to buffer the acid more effectively and allow muscles to continue working for longer, so the cell starts to produce increased levels of intracellular buffers.

In the long term, with repeated cycles of training and recovery and the provision of adequate nutrients from a healthy balanced diet:
The hamstrings get stronger and can lift more weight on the leg curl.
There is more actin and particularly myosin content within muscle fibres.
The muscle fibres increase in size and cross-sectional diameter.
There is more energy available in the form of increased PCr stores and glycogen.
Lactic acid can be tolerated more effectively due to increased concentrations of intramuscular buffering compounds.

An example of the changes that result from performing muscular strength training:
Consider the following adaptations to RT and decide whether they are adaptations that occur in response to muscular endurance, hypertrophy or muscular strength training. Then indicate whether they are short-term or long-term adaptations. An example is given:

<table>
<thead>
<tr>
<th>Adaptation</th>
<th>Type of training</th>
<th>Short-term or long-term</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Muscular endurance</td>
<td>Hypertrophy</td>
</tr>
<tr>
<td>➡ size of type 1 and type 2 fibres</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>neural fatigue</td>
<td></td>
<td></td>
</tr>
<tr>
<td>➡ enzyme activity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>➡ blood flow to muscles</td>
<td></td>
<td></td>
</tr>
<tr>
<td>➡ number of mitochondria</td>
<td></td>
<td></td>
</tr>
<tr>
<td>➡ intramuscular lactic acid</td>
<td></td>
<td></td>
</tr>
<tr>
<td>➡ maximal strength</td>
<td></td>
<td></td>
</tr>
<tr>
<td>improved neuromuscular communication</td>
<td></td>
<td></td>
</tr>
<tr>
<td>➡ breakdown of glucose and fatty acids to produce energy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>➡ energy stores within muscles</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Resistance training and posture

Any resistance training exercise has the potential to improve posture if used appropriately. It also has the potential to make posture much worse if applied incorrectly. Although postural analysis is a skill covered in level three personal training qualifications, fitness instructors need to be observant and programme to a participant’s needs as well as their desires.

When meeting customers, fitness professionals need to look at the way they stand, sit, walk and move when performing different exercises. It will soon become apparent if someone has postural problems such as rounded shoulders, arched or flat lower back or tight, inwardly rotated shoulders.

People’s posture is a result of the body structure they have inherited (genetics), any medical conditions they may have had from birth (congenital abnormalities) and the lifestyle they have lived. Those who have spent their life standing and moving around, and maintained a healthy body weight, are likely to have a very different posture from those who have spent years sitting down, especially if as a result if inactivity they have gained weight and now have an unhealthy level of body fat.

Resistance training will not resolve all postural problems but it can certainly help to correct poor posture caused by muscle imbalance across joints. Strengthening core muscles will help posture and should be part of any training programme. Including exercises to strengthen the muscles that act as antagonists to tight muscles within a session can further benefit posture.

Example of programme design to improve posture:

You notice that a customer has a kyphotic posture (rounded shoulders and excessive curve in the thoracic spine) and they tell you there is no medical reason for this. They use a computer regularly and spend a lot of time sitting down. When you show them some stretches it seems they have tight chest and latissimus dorsi muscles but weak upper back (trapezius and rhomboid) and shoulder muscles.

A suitable programme to recommend would include a balanced core strength and stability programme such as back raises and abdominal plank, along with exercises involving horizontal extension such as prone fly or wide grip seated row.

Delayed onset muscle soreness

Delayed onset muscle soreness (DOMS) is a phenomenon that typically occurs 24 to 72 hours after resistance training although it has been reported that this can continue to be experienced for up to nine days after training.

DOMS is characterised as a dull, aching type pain experienced in muscles after unaccustomed or strenuous exercise, which may be accompanied by stiffness. It is tender when pressure is applied to affected muscles. The pain and sensitivity is caused by microtrauma to muscle fibres and the subsequent inflammatory response.

DOMS is part of the normal repair process of muscle and is thought to be essential in order for hypertrophy to occur. Although any unaccustomed exercise can cause DOMS, certain types of exercise are strongly associated with it. Eccentric or negative contractions (the lowering phase of an exercise) and high impact exercises or jumping exercises such as plyometrics, which have intense eccentric loading phases cause the worst DOMS.
Delayed onset muscle ............... (DOMS) is a phenomenon that typically occurs 24 to 72 hours after ................. training although it has been reported that this can continue to be experienced for up to nine days after training.

DOMS is characterised as a dull, aching type pain experienced in muscles after ................. or ................. exercise, which may be accompanied by stiffness. It is tender when pressure is applied to affected muscles. The pain and sensitivity is caused by ....................... to muscle fibres and the subsequent inflammatory response.

DOMS is part of the normal repair process of muscle and is thought to be essential in order for ....................... to occur. Although any unaccustomed exercise can cause DOMS, certain types of exercise are strongly associated with it. ....................... or negative contractions (the lowering phase of an exercise) and high impact exercises or jumping exercises such as ....................... which have intense eccentric loading phases cause the worst DOMS.

Missing words: hypertrophy, strenuous, eccentric, resistance, micro-trauma, unaccustomed, soreness, plyometrics

Summary

You should now know that RT is a type of weight-bearing exercise making it beneficial for bone health.

- RT has been shown to have a greater effect on a larger number of sites throughout the skeleton than CV exercise.
- RT can worsen wear and tear damage to joints, so care must be taken when performing RT regularly.

You should now understand that RT, when performed regularly, will result in certain short and long-term muscular adaptations, which will be dependent upon the type of training performed; for example, muscular endurance training, hypertrophy training or muscular strength training.

You should now know that RT can result in improved posture when performed appropriately but it can also make it worse if performed incorrectly.

- If poor posture is identified, remedial RT can be performed to help improve it.

You should now understand how delayed onset muscle soreness (DOMS) occurs approximately 24 to 72 hours after exercise and is most likely after eccentric exercise or in those unaccustomed to exercise.
### Section 5: Effects of flexibility training on the body

#### Learning outcomes

- To know the short and long-term effects of flexibility training on muscle.
- To understand how flexibility training can improve posture.

#### Effects of flexibility training on muscle

Flexibility training refers to the performance of developmental stretching with the aim of improving the range of movement (ROM) around a joint. Developmental stretching involves the gradual lengthening of a muscle or muscle group into an elongated position and the subsequent 'hold' of this position. Current evidence suggests that developmental stretches should be held for 20 to 30 seconds and repeated two to five times for optimal benefits. Adaptations take place within the muscles which result in enhanced ROM.

Developmental stretching can be performed around any joint but consider the example shown in table 5.1 of what happens to the hamstrings muscle group in the short and long term.

#### Table 5.1 The short and long-term effects of stretching on the hamstrings muscle group.

<table>
<thead>
<tr>
<th>Muscular action</th>
<th>Short-term effects</th>
<th>Long-term adaptations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relaxation and stretching of the muscle and the associated fascia.</td>
<td>sarcomere length and overlap between actin and myosin filaments allows muscles to lengthen activity of motor neurons which innervate stretched muscles, and ROM specific to the area being stretched which lasts approximately 30 minutes.</td>
<td>ROM specific to the joint being stretched resting muscle length muscle tightness (tonicity) number of sarcomeres at the end of the muscle fibre – this is a slow process, and training of the stretch receptors which allows greater lengthening of the muscles before they fire and cause muscular contraction.</td>
</tr>
</tbody>
</table>

Changes in sarcomere length and overlap between actin and myosin filaments allow muscles to lengthen. Activity of motor neurons which innervate stretched muscles, and ROM specific to the area being stretched lasting for approximately 30 minutes.

Changes in resting muscle length and muscle tightness (tonicity) number of sarcomeres at the end of the muscle fibre – this is a slow process, and training of the stretch receptors which allows greater lengthening of the muscles before they fire and cause muscular contraction.
Learning activity 5.1

In your own words, describe the short-term and long-term adaptations to flexibility training.

Short-term

Long-term

Summary

You should now know that appropriate, well-performed flexibility training will result in certain muscular improvements.

- In the short term, there will be a short-lived increase in ROM.
- In the long term, there will be an increase in a muscle’s resting length and an increase in ROM amongst other factors.

You should now know how flexibility training can improve posture in combination with a balanced RT programme by helping to reduce muscular tightness.

Flexibility training and posture

Although it is believed that stretching alone is an ineffective way to improve posture, flexibility training can assist a balanced resistance training programme in achieving this goal.

Performing developmental stretching on a regular basis will reduce muscular tightness and increase the resting length of the muscles which have been stretched. As muscles form integral parts of joints, tight muscles can have an effect on joint structure and function. If, for example, the muscles on one side of a joint are tight, developmental stretching will lengthen these muscles and could result in the more effective functioning of this joint.

In terms of posture, regular developmental stretching of key postural muscles combined with a balanced resistance training programme will result in lengthened and strengthened muscles which will allow for improved posture. If, for example, people have a kyphotic posture with tight chest and latissimus dorsi muscles, it would be advisable for them to carry out developmental stretches for the pectoral muscles and latissimus dorsi.
Learning outcomes

☐ To know different methods of monitoring exercise intensity.

☐ To understand the benefits and limitations of different methods of monitoring exercise intensity.

Talk test

The ‘talk test’ is a method of monitoring intensity that simply involves speaking to the people exercising to determine whether or not they are able to talk comfortably. Sometimes it is easier to ask the exerciser to repeat a specific sentence or paragraph every so often and judge the way in which they respond (some trainers ask people to recite national anthems or sing nursery rhymes). If people are working at a moderate intensity, they will be able to talk back comfortably.

Benefits

- a very practical and simple way to monitor intensity in steady state exercise
- no equipment is required
- accurately determines exercise intensity across different exercise modes
- research shows that the point at which speech first becomes difficult is equivalent to the ventilatory threshold (VT) and when speech is no longer comfortable, exercise intensity is above VT (Persinger et al, 2004), and
- suitable for the majority of exercisers.

VENTILATORY THRESHOLD (VT)

As exercise intensity increases, ventilation increases in a linear manner until it reaches an intensity whereby the ventilatory demands of the body are greater than the body’s ability to achieve them and at this point ventilation increases rapidly (exponentially). This point is known as VT. It is a good marker to use to assess fitness progression because as people become fitter their VT will occur at higher exercise intensities.

Limitations

- gives limited specific feedback about intensity, and
- has limited use during interval training.
Rate of perceived exertion

Rating of perceived exertion (RPE) is a subjective measure of exercise intensity that involves asking the people who are exercising to rate how hard they feel that they are working at any given point. The rating is given against a pre-determined scale.

The original Borg rating of perceived exertion (Borg, 1982) scale is a 6 to 20 scale which increases linearly in intensity alongside other measures of intensity, for example, heart rate and VO₂. The Borg scale is shown in figure 6.1.

Figure 6.1 Original Borg scale 6 to 20.

<table>
<thead>
<tr>
<th>Rating</th>
<th>Perception of effort</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Very, very light</td>
</tr>
<tr>
<td>7</td>
<td>Very, very light</td>
</tr>
<tr>
<td>8</td>
<td>Very light</td>
</tr>
<tr>
<td>9</td>
<td>Fairly light</td>
</tr>
<tr>
<td>10</td>
<td>Somewhat hard</td>
</tr>
<tr>
<td>11</td>
<td>Somewhat hard</td>
</tr>
<tr>
<td>12</td>
<td>Hard</td>
</tr>
<tr>
<td>13</td>
<td>Very hard</td>
</tr>
<tr>
<td>14</td>
<td>Very hard</td>
</tr>
<tr>
<td>15</td>
<td>Very, very hard</td>
</tr>
<tr>
<td>16</td>
<td>Very, very hard</td>
</tr>
<tr>
<td>17</td>
<td>Very, very hard</td>
</tr>
<tr>
<td>18</td>
<td>Very, very hard</td>
</tr>
<tr>
<td>19</td>
<td>Very, very hard</td>
</tr>
<tr>
<td>20</td>
<td>Very, very hard</td>
</tr>
</tbody>
</table>

Some people, however, found it difficult to relate to a 6 to 20 scale, so a second scale was developed based upon a 0 to 10 scale. This is known as the category ratio 10 or CR10 RPE scale. The CR10 scale is not linear and is often a more useful measure of exercise intensity due to people’s familiarity with 0 to 10 scales. The CR10 scale is shown in figure 6.2.

Both of these scales have been validated for use but it is important to note that they should be visible to participants during the exercise and that they have been designed with the intention of asking which of the descriptors best applies rather than focusing on the numbers exclusively. A proportion of the population just cannot use these scales to effectively rate their exercise intensity: inexperienced exercisers in particular often struggle as they are unfamiliar with training and all exercise seems hard.

Figure 6.2 The adapted Borg category ratio 10 scale.

<table>
<thead>
<tr>
<th>Rating</th>
<th>Perception of effort</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Nothing at all</td>
</tr>
<tr>
<td>0.5</td>
<td>Very, very weak (just noticeable)</td>
</tr>
<tr>
<td>1</td>
<td>Very weak</td>
</tr>
<tr>
<td>2</td>
<td>Weak</td>
</tr>
<tr>
<td>3</td>
<td>Moderate</td>
</tr>
<tr>
<td>4</td>
<td>Somewhat strong</td>
</tr>
<tr>
<td>5</td>
<td>Strong (heavy)</td>
</tr>
<tr>
<td>6</td>
<td>Strong (heavy)</td>
</tr>
<tr>
<td>7</td>
<td>Very strong</td>
</tr>
<tr>
<td>8</td>
<td>Very, very strong (almost maximal)</td>
</tr>
<tr>
<td>9</td>
<td>Very, very strong (almost maximal)</td>
</tr>
<tr>
<td>&gt;10</td>
<td>Maximal</td>
</tr>
</tbody>
</table>

Benefits

- easy to use
- very little equipment required
- can be used alongside Heart Rate (HR) to give an overall picture of exercise intensity, and
- suitable for the majority of exercisers.

Limitations

- subjective measures of intensity are not accurate measures of physiological changes
- some people are unable to use numbered scales effectively, and
- novice exercisers find RPE scales more difficult to use.
Heart rate monitoring

Heart rate (HR) monitoring is an objective way to measure exercise intensity. The most accurate way to assess HR is to use a HR monitor which will either display the HR on a watch or, if the two are compatible, on the CV machine being used.

Benefits
- objective measure of exercise intensity, and
- accurate measure of exercise intensity.

Limitations
- not suitable for all exercisers, especially those who take certain medications such as beta blockers
- requires HR monitoring equipment, and
- requires the individual to wear a HR monitor, which may not be comfortable, or even possible, depending upon the person’s body shape and size.

Learning activity 6.1

Identify some of the key benefits and limitations for each of the following methods of monitoring intensity:

<table>
<thead>
<tr>
<th>Method</th>
<th>Benefits</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Talk test</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RPE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heart rate monitoring</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

There are two methods that can be used to prescribe exercise intensity using HR: the maximum HR method (HR_{max}) and the HR reserve (HRR) method.
Using the $HR_{max}$ method

In order to use the $HR_{max}$ method, individuals must know, or be able to estimate their $HR_{max}$. Directly measuring $HR_{max}$ is the most accurate way of finding this out and results in more accurate prescription of training intensity. To directly measure $HR_{max}$, people can undertake a progressive, maximal exercise test such as the multi-stage fitness test (MSFT) while wearing a HR monitor or a laboratory based graded maximal treadmill test.

It is often not possible or safe, however, to carry out this type of testing with participants. If this is the case, it is possible to estimate $HR_{max}$ using a standard, age-predicted equation as shown in figure 6.3. It should be noted that estimating $HR_{max}$ in this way has an error margin of up to 30bpm.

**Figure 6.3 Age-predicted $HR_{max}$ equation.**

*Age-predicted equation = $HR_{max}$ (bpm) = 220 - age (years)*

For example, Jane is 40 years old and wants to estimate her $HR_{max}$ using the age-predicted equation:

1. Minus Jane’s age from 220: $220 - 40 = 180$
2. Result is $HR_{max}$ (bpm): 180bpm

Jane’s estimated $HR_{max}$ is 180bpm

To use the estimated $HR_{max}$ to guide a training session it is necessary to calculate the appropriate percentage of this figure according to desired training intensity. Figure 6.4 shows how to do this.

**Figure 6.4 Calculating training intensity from $HR_{max}$.**

*Percentage of $HR_{max} = (HR_{max}$ (bpm) x desired %) / 100*

For example, Jane wants to work at 80% of her $HR_{max}$:

1. Multiply $HR_{max}$ by desired %: $180 \times 80 = 14400$
2. Divide result by 100: $14400 / 100 = 144$
3. Result is target HR (bpm): 144bpm

For Jane to work at 80% of her estimated $HR_{max}$, she will need to exercise at 144bpm.

---

**Learning activity 6.2**

John is a 35 year old man. In the space below:

Work out John’s estimated $HR_{max}$ using the age-predicted equation:

Work out what HR John would have to work at to achieve 75% $HR_{max}$:

Now use your own age and calculate your estimated $HR_{max}$:

Now calculate your target heart rate at each of the following intensities:

- 50%
- 60%
- 70%
- 80%
- 90%
Using the HRR method

The HRR method takes into account resting HR (RHR) when prescribing training intensity and is also known as the Karvonen method (after the person who developed it). RHR is thought to be an important inclusion in the equation as it decreases as a person becomes fitter. HRR is the difference between HRmax and RHR and it will increase as a person becomes fitter.

In order to work out HRR, it is necessary to know a person’s RHR. This is best measured first thing in the morning before getting out of bed or, if this is not possible, after 10 to 15 minutes of lying down in a quiet place. HRmax is also needed in order to calculate HRR and this can be measured directly or estimated as previously described.

Once RHR and HRmax are known, HRR can be estimated using the equation shown in figure 6.5.

**Figure 6.5 Calculation for HRR.**

\[
HRR (\text{bpm}) = HR_{\text{max}} - RHR
\]

For example, Jane wants to calculate her HRR. Her RHR is 70 and her HRmax was estimated as 180bpm.

1. Minus Jane’s RHR from her HRmax 180 - 70 = 110
2. Result is HRR (bpm) 110bpm

Jane’s HRR is estimated to be 110bpm

As with the HRmax method, to use HRR to prescribe training intensity it is necessary to carry out further calculations as shown in figure 6.6. These calculations are a little longer than those required in the HRmax method due to having to subtract RHR at the beginning then add it back in after the %HRR has been worked out.

**Figure 6.6 Calculating training intensity from HRR.**

\[
\text{Percentage of } HRR = \frac{(HRR (\text{bpm}) \times \text{desired } \%)}{100} + RHR
\]

For example, Jane wants to work at 80% of her HRR.

1. Multiply HRR by desired % 110 x 80 = 8800
2. Divide result by 100 8800 / 100 = 88
3. Add RHR to result 88 + 70 = 158
4. Result is target HR (bpm) 158bpm

For Jane to work at 80% of her estimated HRmax she will need to exercise at 158bpm
Workbook

Level 2

Principles of Exercise, Fitness and Health

Learning activity 6.3

John, the 35 year old man from learning activity 6.2, has a RHR of 60. Work out the following in the space below:

John’s estimated HRR using the Karvonen formula:

What HR John would be working at to achieve 75% HR_{max} using the HRR / Karvonen method:

Now use your own age to estimate your HR_{max} and measure your own RHR then work out your HRR in the space below:

Now calculate your target heart rate at each of the following intensities using the HRR / Karvonen method:

- 50%
- 60%
- 70%
- 80%
- 90%

How did these compare to the results you got for the HR_{max} calculation?

Summary

You should now know numerous different methods of monitoring exercise intensity including:

- the talk test
- rating of perceived exertion, and
- heart rate monitoring.

You should now understand that each method of monitoring exercise intensity has benefits and limitations including:

- whether it is suitable for all people
- whether it is subjective or objective
- whether it is easy to administer, and
- whether it requires much equipment.
Learning outcomes

☐ To understand the principles of programme design.
☐ To know the F.I.T.T. training variables and how to apply them.
☐ To understand the principles of a progressive programme design in developing components of fitness.
☐ To understand how to adapt, modify and progress each of the components of the F.I.T.T. principle.
☐ To be able to recognise when and how to regress a training programme.
☐ To know the effect of levers, gravity and resistance on exercise.
☐ To know the effects of speed on posture, alignment and intensity.
☐ To understand the differences between programming exercise for physical fitness benefits and for health benefits.

The principles of programme design

Well-planned training allows individuals to reach their training goals without risking illness or injury. The principles of programme design ensure that programmes are effective and efficient and progress at a suitable pace. These principles are applicable to men and women and across a broad age range.

Overload

The fundamental principle of fitness is overload. The human body is, essentially, lazy and if it is not challenged or stressed it will not adapt or improve. Overloading the body challenges it beyond its current capacity and creates the stimulus that it needs to adapt. Through these adaptations, the body’s function and efficiency is enhanced.

Performing exercise at the same intensity for the same duration and on the same number of days per week, month after month will not result in any fitness improvements. By increasing the intensity, frequency or duration of training, overload is created, the body is challenged and it will adapt by becoming fitter. Only one of these variables should be increased at a time.

One thing that must be remembered is that the initial response to overload is fatigue. It is important, therefore, that adequate recovery time is programmed following the overload as this is when the adaptations take place.

Progression

Progression is a continuation of the overload principle and refers to the fact that, after the initial overload, further overload needs to be applied in order to create the necessary stimulus and the adaptations. Progression and overload are often coupled together and called ‘Progressive Overload’. Quite simply, if no progression is applied no further fitness improvements will be seen.

It is important to remember that progression should be gradual. If it is too slow, improvements will be unlikely and hard to perceive. If it is too fast, injury or illness may occur.
Specificity
This principle relates to the fact that the body will only adapt according to the exact type of overload that is placed upon it; for example, endurance exercise will primarily develop the long-term aerobic energy system.

In addition, training adaptations will be sport-specific which explains why swimmers need to swim and runners need to run in order to improve performance. Sport-specific training ensures that the appropriate muscles and energy systems are used in exactly the right way and that adaptations will enhance performance in that sport.

Reversibility
If individuals stop training they will start to lose any adaptations that they had achieved: this is called ‘de-training’. Basically, fitness adaptations are reversible so no-one can afford to be complacent! After just one to two weeks of de-training, fitness will be noticeably reduced and it can take just a few months to lose training adaptations completely if no activity at all is performed. This explains why many sports people continue to train through the off-season.

Learning activity 7.1
Which principle of training relates to each of the following statements? An example is given.

Training adaptations will relate to the type of training that is performed:

Specificity
In order to develop fitness, the body needs to be challenged:

Endurance exercise will primarily develop the long-term energy system:

If individuals stop training they will start to lose their fitness:

After initial overload, further overload needs to be applied in order to improve fitness:
There are a number of other factors to consider when designing a training programme.

**Individuality**

Everybody is different! This means that everybody will respond to training in a different way and programmes need to be designed to account for individual differences. By designing programmes in this way, they become specific to the person performing them rather than generic.

Alongside individuality, ‘trainability’ will affect the way that a person responds to a training programme. It refers to the ability to become trained: how well people respond to the training that they perform. Trainability is determined by physiological factors such as heart and lung size, muscle fibre characteristics and physique. Individual differences such as age, gender, current fitness, medical history, nutritional status and lifestyle, along with trainability, all need to be considered when designing fitness programmes.

**Recovery time**

Some scientists argue that recovery is the most important part of a training programme. The theory being that without recovery fitness adaptations will not take place. The training period only provides the stimulus for development; the recovery period allows the adaptations to take place. The continuous cycle of overload, recovery and adaptation takes an individual to a higher level of fitness.

**Adaptability**

In order for a programme to be successful, it needs to be adaptable. Whilst it is impossible to account for every possibility, it is important that training programmes are designed with a degree of flexibility. A programme that is too ‘strict’ will ultimately fail the exerciser as there will come a time when it is necessary for the programme to adapt to the person’s needs.

---

**The F.I.T.T. principle**

The variables of fitness training can be remembered by using the acronym F.I.T.T. By adapting these variables, programmes can be designed that will suit the majority of people.

<table>
<thead>
<tr>
<th>F.I.T.T. STANDS FOR:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
</tr>
<tr>
<td>Intensity</td>
</tr>
<tr>
<td>Time</td>
</tr>
<tr>
<td>Type</td>
</tr>
</tbody>
</table>

**Frequency**

Frequency refers to the **number of training sessions that are carried out** per week; that is, how often training is performed.

**Intensity**

This variable refers to **how hard a person works** during a training session. The intensity of training is probably the most important factor when it comes to improving fitness as there is a threshold, below which, no significant adaptations will occur. On the other hand, training at too high an intensity will result in the individual being unable to complete the prescribed duration.

**Time**

Time refers to the **duration of the training session**. The duration of training is inversely related to its intensity; the more intense a session is, the shorter the duration needs to be in order to gain the fitness benefits.

**Type**

The type or mode of exercise performed may affect the fitness benefits achieved. When choosing the mode of exercise, the specificity principle must be considered. The exercise that is prescribed should be specific to the individual’s preferences, needs and goals. It is also important to remember the principle of individuality and consider individual needs when choosing exercise type; for example, high impact exercise is not recommended for overweight individuals.
A progressive programme is one that has a planned structure of overload and recovery and continues to provide sufficient increases in overload over a period of time to carry on stimulating adaptations during recovery periods. The F.I.T.T. variables will be modified over time to provide an appropriate balance of stimulus and response for the individual. If the relative amounts of work and recovery are right for the person performing the programme the desired goals will be achieved. If there is too little stimulus or too much recovery any progress will be slow. The most important things to avoid are too much stimulus or too little recovery as these can lead to injury, illness or overtraining syndrome.

Generally it is advisable to progress only one F.I.T.T. variable at a time during a programme. The examples below show how to progress different components of fitness within a training programme:

**Progressing CV fitness using increased frequency of training**

If someone wished to improve cardiovascular fitness and was not currently exercising it would be fitting to programme three cardiovascular training sessions per week on non-consecutive days. This would be ideal because it reflects the minimum frequency of training recommended in the ACSM guidelines for improving CV fitness above health-related levels. In many cases, however, a new exerciser will be unable or unwilling to commit to three exercise sessions per week and may start with just one. One exercise session per week may not provide optimal physiological benefit but it will help to improve people’s self esteem and their confidence in their ability to exercise. Furthermore, evidence shows that the people who manage to complete one exercise session per week for the first four weeks of their programme are likely to still be exercising in one year’s time. To progress such a programme to afford the individual more physical benefit the first option should be to increase the frequency of the sessions.
Progressing muscular fitness using duration of training (time)

Consider a resistance training programme and a scenario where someone is already performing three exercise sessions per week and training all major muscle groups with one set of 10 repetitions each time. In this case increasing frequency of exercise would not be advised as this would exceed the recommended number of sessions and prevent adequate recovery time for the body to adapt to the training stimulus. In order to progress this programme it may be better to increase the volume of training within the exercise sessions. By increasing the session to two sets of each exercise the increased workload during the sessions will stimulate adaptation and there will still be adequate recovery time between sessions to allow adaptations to occur.

Progressing muscular fitness using intensity

Continuing with the example of resistance training, if the exerciser didn’t have time to stay in the gym for two sets of each exercise, the programme could be progressed by increasing the intensity of the exercise. Although it is usually preferable to increase volume of exercise before intensity in a programme, lifting heavier weights for eight repetitions would increase the intensity of the session and stimulate further adaptation even if only one set was performed. When progressing to a heavier weight, fewer repetitions can be performed to a point of fatigue. A good rule of thumb as to when people are ready to progress to lifting heavier weights is when they are able to perform the maximum number or repetitions in the desired range; for example, 12 reps if training for hypertrophy, two sets in a row, two workouts in a row. Likewise with increasing the intensity of a CV session, if an exerciser can perform a certain distance in a certain time for two consecutive weeks the intensity could be increased by increasing the pace (but not at the same time as increasing session duration).

Progressing flexibility using type of exercise

Type of training can also be varied to progress a programme. This could mean performing a different exercise; for example instead of stretching the gastrocnemius muscle standing in a split stance and pushing the heel of the back leg into the floor, an alternative stretch using a step or sitting on the floor and pulling the foot with a towel could be performed.

Table 7.1, overleaf, summarises how to progress each of the main elements of a training programme using the F.I.T.T. variables.
Table 7.1  Summary of the application of F.I.T.T. variables to components of fitness.

<table>
<thead>
<tr>
<th>Component of training / programme variable progression</th>
<th>Cardiovascular fitness</th>
<th>Muscular fitness</th>
<th>Flexibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>Increase the number of sessions towards three non-consecutive days initially. Once a client is performing this regularly increase up to five sessions of different intensities.</td>
<td>Increase the number of sessions towards two full body routines initially, then up to three with at least 24 hours rest between each.</td>
<td>Perform flexibility training after every exercise session as a minimum. Progress towards three sessions per week initially of static, developmental and maintenance stretches then increase towards daily stretching.</td>
</tr>
<tr>
<td>Intensity</td>
<td>Use either resistance / incline / harder exercise variations, or use speed increments to increase intensity. Monitor regularly during sessions and stay within guidelines for safe exercise intensity.</td>
<td>Increase loads when the highest number of reps in the desired range can be achieved for two sets in two consecutive sessions. Increase by the smallest available increment.</td>
<td>Only ever take a stretch to a point of mild discomfort, never to a point of pain.</td>
</tr>
<tr>
<td>Time (duration)</td>
<td>Follow the 10% rule of thumb. Keeping all other programme variables equal, exercise distance / time in any one session or over a week can be progressed by up to 10%. It is advisable to include an active recovery week every fifth week where duration does not increase to prevent overuse / overtraining.</td>
<td>One to three sets per exercise are appropriate. Start with one set in a programme and increase the training by adding a second, then third set when plateaus in progress occur.</td>
<td>Ten to 15 seconds is adequate for a maintenance stretch to help return a muscle to its resting length following exercise. Developmental stretches of 30+ seconds performed one to three times at the end of an exercise session can increase muscle length and ROM.</td>
</tr>
<tr>
<td>Type</td>
<td>If training for a specific goal, the mode of exercise will be dictated by that goal; for example, marathon = running. If training for weight loss / general fitness and health a mixture of training modes enjoyed by the participant should be included. Some cross training sessions can be included in all programmes, especially when training on consecutive days to facilitate recovery.</td>
<td>Although compound exercises will be most beneficial for the majority of people a range of exercises and modes; for example, fixed machines / free weights / bodyweight, will be appropriate for participants at different points in the programme.</td>
<td>Dynamic stretches are recommended pre-exercise and static maintenance and developmental stretches after. Whether a muscle group requires a maintenance or developmental stretch should be determined based on the participant’s posture, lifestyle and exercise programme.</td>
</tr>
</tbody>
</table>
Learning activity 7.3
Identify which component of training and which of the F.I.T.T. variables are being addressed in each of the following statements. An example is given.

Increase the number of sessions towards three non-consecutive days initially. Once a client is performing this regularly increase up to five sessions of different intensities.
Component of training: **Cardiovascular fitness**
F.I.T.T. variable: **Frequency**
Increase loads when the highest number of repetitions in the desired range can be achieved for two sets in two consecutive sessions. Increase by the smallest available increment.
Component of training:
F.I.T.T. variable:

If training for a specific goal, the mode of exercise will be dictated by that goal; for example, marathon = running. If training for weight loss / general fitness and health a mixture of training modes enjoyed by the participant should be included. Some cross training sessions can be included in all programmes, especially when training on consecutive days to facilitate recovery.
Component of training:
F.I.T.T. variable:

Ten to 15 seconds is adequate for a maintenance stretch to help return a muscle to its resting length following exercise. Developmental stretches of 30+ seconds performed one to three times at the end of an exercise session can increase muscle length and ROM.
Component of training:
F.I.T.T. variable:
Increase the number of sessions towards two full body routines initially, then up to three with at least 24 hours rest between each.
Component of training:
F.I.T.T. variable:
Regressing a training programme

Regression is the opposite of progression and may be necessary in a training programme when a client is experiencing:

- over-reaching, or
- over-training syndrome (OTS).

There is a dose-response relationship between exercise and the adaptations it causes. The greatest difference is observed when someone performs some training as opposed to none. An increased frequency of training will cause additional adaptations to a point. Once the optimal balance of work to recovery in a programme has been achieved further exercise sessions will shorten the recovery to such an extent that fitness will actually get worse rather than better. This fact is illustrated in figure 7.2.

![Figure 7.2 Bell curve showing the dose-response relationship of exercise frequency to fitness improvement.](image)

Fitness improvement

It is important to monitor clients’ responses to any changes in their training programme, particularly an increase in volume of training through an increased duration or most importantly frequency of training. If clients are training more often yet seeing no improvements in their fitness this indicates over-reaching and a need to regress the programme. This would be the case particularly if the plateau in performance was associated with joint or muscle aches above a normal level after training, catching infections or generally feeling low on energy or under the weather.

If performance does not improve or symptoms do not subside after two or three week rest from training this indicates that the client may be in a state of over-training. This is a complex condition with no single diagnostic criteria and a client should be referred on to an appropriate medical professional if there is any suspicion that they may be suffering from OTS.
Factors that affect exercise intensity

**Speed of movement**

With cardiovascular exercise, the faster the pace, the harder the exercise intensity. For resistance exercise, however, speed of movement can have different effects. Slow movement speeds can be used to make an exercise more intense by reducing momentum and forcing the exerciser to use muscular effort to lift the weight. Normal lifting speeds of one to two seconds for the lifting (concentric) phase and three to four seconds for the lowering (eccentric) phase can be slowed to around five to ten seconds each in a technique known as super-slow training. This is a useful way to increase the intensity of bodyweight exercises. Fast movement speeds can also be used to make exercises more intense as when performing explosive lifts for developing power.

**Lever length**

When performing resistance exercises, the length of the body lever from the fulcrum can be used to increase the intensity. A common example of this might be in abdominal training where hand position can be changed to move the centre of gravity further up the body, effectively increasing the distance of the upper body load from the fulcrum at the lumbar spine. In free weight exercise a lateral raise provides a good example; by keeping elbows straight when lifting arms out to the sides the exercise is more intense than if elbows are bent, which shortens the lever length from the shoulder to the weight and makes the exercise easier.

**Range of movement**

In most cases, the greater the range of movement the harder the exercise. Some parts of a range of movement are harder than others and often people will shorten the ROM to stay within the easy segment. Using the full range of movement about a joint uses all of the muscles on that aspect of the joint and strengthens function through the full range, whereas using a smaller ROM will only strengthen movement through that restricted range so is considered less functional. A bicep curl, for example, should be performed from a starting position with elbows straight. The elbows should then be flexed until the weights reach the shoulders. Many people performing this exercise in the gym, however, will make it easier by restricting the range of movement and not fully extending the elbows.

**Rest period**

Shortening rest periods reduces the amount of recovery that occurs between sets or exercises. If full recovery is not taken the second or subsequent sets will be harder as the muscles will already be partially fatigued before beginning the exercise. Shortening recovery is a method that can be used to increase session intensity by increasing the training density (amount of exercise performed in a given amount of time). This has also been linked to improved metabolic effects from exercise. Shortening rest periods too much too soon, however, can leave clients feeling exhausted and performing poorly on later sets or exercises. This can result in smaller benefits from training.

**Resistance**

The heavier the load or higher the resistance the harder the exercise will be.
When performing exercises a suitable speed of movement should be chosen that is specific to the purpose of the exercise. If performing a programme to improve sporting performance it may be appropriate to use faster movement speeds than when exercising for general health or fitness. It is always essential that clients are able to maintain good posture and exercise technique whatever the speed at which they are exercising. If posture is lost or technique fails the exercise should be slowed down or stopped. In general, it takes more core control and muscular strength to control fast movement speeds than slower ones and it is important to make sure a participant is well conditioned before performing fast or explosive training.

### Learning activity 7.4

**In your own words, explain how each of the following affects exercise intensity:**

<table>
<thead>
<tr>
<th>Factor</th>
<th>How it affects exercise intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed of movement</td>
<td></td>
</tr>
<tr>
<td>Lever length</td>
<td></td>
</tr>
<tr>
<td>Range of movement</td>
<td></td>
</tr>
<tr>
<td>Rest period</td>
<td></td>
</tr>
<tr>
<td>Resistance</td>
<td></td>
</tr>
</tbody>
</table>

### Programming for fitness versus programming for health

There are differences between programming exercise for physical fitness and programming exercise for health benefits. When programming for a sport-specific fitness goal, the central element of the programme must be the sport-specific training as this is the most important thing to the exerciser. Although it is ideal to keep some balance between different aspects of a programme, it would not always be appropriate, for example, to programme three resistance training sessions per week for cyclists: the resultant muscle fatigue might reduce their opportunity to cycle regularly or to perform at their best when cycling.

When programming for health the components of the programme can be balanced around the participant’s needs and will tend to contain similar numbers of CV and resistance training sessions. The intensities differ too; someone wishing to achieve optimal performance in their sport will be willing to push themselves in sessions and perform exercise at a level that is uncomfortable. This level of intensity is not necessary to achieve health-related goals and it would be unwise to programme hard sessions if the effect will be to put a participant off exercising regularly.
Summary

You should now be able to explain each of the principles of programme design:

- specificity
- overload
- progression
- reversibility
- individuality
- recovery time, and
- adaptability.

You should now understand how the F.I.T.T. principle can be used to programme and progress exercise by varying:

- Frequency
- Intensity
- Type, and
- Time.

You should be able to use the principles of a progressive training programme to develop components of fitness in a programme.

You should know how to adapt, modify and progress each of the components of the F.I.T.T. principle.

You should be able to recognise when and how to regress a training programme.

You should understand the effect of levers, gravity and resistance on exercise.

You should be able to describe the effects of speed on posture, alignment and intensity.

You should know the difference between programming exercise for physical fitness benefits and programming exercise for health benefits.
Section 8: Guidelines for special populations

Learning outcomes

☐ To know the exercise contraindications and key safety guidelines for working with older people (aged 50 plus).

☐ To know the exercise contraindications and key safety guidelines for working with antenatal and postnatal women.

☐ To know the exercise contraindications and key safety guidelines for working with young people (aged 14 to 16).

☐ To know the key safety considerations for working with disabled people.

Professional boundaries

As with all other groups in the population, the ‘special population’ groups covered in this section are made up of individuals. General guidelines are discussed but it is vital to remember that each group will contain people with a wide range of physical and physiological capabilities.

If the pre-participation screening reveals factors that could contraindicate physical activity, individuals must be referred to the appropriate professional; for example, their GP or other medical professional, before taking part in physical activity. If individuals have been advised to take part in physical activity by a healthcare professional, it is imperative that they stick to the guidelines / restrictions provided. They must also consult their healthcare professional regularly to ensure that their activity programme remains suitable for them.

Fitness professionals working with special population groups should observe their own professional boundaries and remember that it would be foolish to work beyond their level of training. By stepping outside of professional boundaries, fitness professionals will not be able to give their clients the service they require or expect. More worryingly, those who work beyond their level of knowledge or expertise risk ‘doing harm’ to a person, which may result in legal action. Those who are not trained in ante and postnatal fitness, for example, should not work with this population group as they would not be aware of the limitations of this physiological state.

Think of professional boundaries outside of fitness: who would take legal advice from a shop assistant or financial advice from a butcher? By sticking to their professional boundaries, people deliver the service that their clients require and the clients receive the service that they expect – everybody is happy.
Workbook

Level 2

Principles of Exercise, Fitness and Health

<table>
<thead>
<tr>
<th>Learning activity 8.1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consider your own professional boundaries and think of three situations in which you would be working outside of them. Note them below:</td>
</tr>
</tbody>
</table>

1. 

2. 

3. 

Working with older people

The UK has an ageing population and this trend is projected to continue. Older people are becoming more aware of the health benefits of physical activity and an increasing number of people over the age of 50 are taking part in exercise. A number of factors need to be taken into account when working with older people.

General considerations

Physical activity programmes for healthy, older people should include a good balance of cardiovascular, resistance, core and flexibility training.

Some general considerations to be taken into account when programming for this group include:

- **Intensity of exercise**: start at a lower intensity and build up slowly especially for older people who are de-conditioned or physiologically limited.

- **Medication**: are the people taking any medication which may influence their capability to exercise or their response to exercise; for example, beta-blockers (high blood pressure medication which alters the HR response to exercise)? If so, do they have their medical professional’s clearance to exercise and do they need to be trained by a fitness professional with an exercise referral qualification?

- **Confidence**: many people over 50 may never have exercised let alone stepped foot inside a gym. This can lead to a lack of confidence when it comes to working out on new equipment in an ‘alien’ environment. It is the fitness professional’s duty to offer support and advice to help boost exercisers’ confidence and make them feel comfortable in their new environment. Progressing exercise slowly and introducing new equipment gradually is important.

- **Balance**: as people age their balance can deteriorate leading to an increased risk of falls and possibly fractures. Older people who are new to exercise need to think about the type of equipment that they use and the type of exercise that they perform – is it safe and appropriate? Although there are no specific recommendations for balance training, the American College of Sports Medicine (ACSM) guidelines (2010) state that neuromuscular training, which aims to improve balance, proprioception and agility, is effective in reducing and preventing falls if performed on two or three days per week.
Programming guidelines

The ACSM guidelines (2010) state that older adults should adhere to the guidelines illustrated in table 8.1 If, however, they cannot perform the recommended amounts of activity because of chronic conditions, they should be as active as their physiological state safely allows.

Table 8.1 Summary of ACSM exercise guidelines for older adults.

<table>
<thead>
<tr>
<th>Training variable</th>
<th>CV training</th>
<th>Resistance training</th>
<th>Flexibility training</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>At least five days a week for moderate intensity activity.</td>
<td>At least two days a week.</td>
<td>At least two days a week.</td>
</tr>
<tr>
<td></td>
<td>At least three days a week for vigorous intensity activity.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Three to five days a week for combination of moderate and vigorous.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intensity</td>
<td>Five or six out of 10 for moderate intensity activity.</td>
<td>Between moderate (five or six out of 10) and vigorous (seven or eight out of 10) intensity.</td>
<td>Moderate intensity (five or six out of 10).</td>
</tr>
<tr>
<td></td>
<td>Seven or eight out of 10 for vigorous intensity activity.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time</td>
<td>Thirty to 60 minutes per session for moderate intensity activity in bouts of at least 10 minutes.</td>
<td>Complete 10 to 15 repetitions of around 8 to 10 exercises</td>
<td>Complete at least one stretch for each major muscle group.</td>
</tr>
<tr>
<td></td>
<td>Twenty to 30 minutes per session for vigorous intensity activity.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type</td>
<td>Activity that does not impose excessive orthopaedic stress.</td>
<td>Progressive programme that involves weight-bearing activity</td>
<td>Activity that maintains or increases flexibility using static, sustained stretches.</td>
</tr>
<tr>
<td></td>
<td>Water or cycle based activity is good for people who cannot perform too much weight-bearing activity.</td>
<td>Exercises that use major muscle groups; for example, step ups.</td>
<td></td>
</tr>
</tbody>
</table>
Many physically active women who become pregnant wish to continue exercising throughout their pregnancy and, if they have a ‘normal’ pregnancy, there is no reason why they should not do so. In fact, research shows that fitter women may have an ‘easier’ pregnancy and birth and find it easier to regain their pre-pregnancy fitness and weight (Varassi et al., 1989).

General considerations
Programming for antenatal and postnatal women needs to take into account their current physiological state as well as their previous exercise history. Some general considerations which need to be considered when programming for this group include:

- **Take advice**: all newly pregnant women are advised to consult their healthcare professional before beginning or continuing with an activity programme, regardless of how experienced an exerciser they are.
- **Balance**: as a woman’s body shape changes so does her centre of gravity which will affect her balance, so this needs to be considered when prescribing activity: activities that could cause a loss of balance need to be avoided.
- **Posture**: changing body shape will also affect a woman’s posture so it is important to include exercises to address this factor in the programme.
- **Overheating**: pregnant women are more at risk of overheating which can be potentially harmful for them and their baby. It is vital that pregnant women who are taking part in exercise maintain adequate hydration levels.
- **Type of exercise**: pregnant women should avoid supine exercise after the first trimester and avoid the Valsalva manoeuvre (forced expiration against a closed glottis – most commonly seen as breath holding when lifting weights).
- **Monitoring intensity**: due to the variability in maternal HR response to exercise, target HR cannot be used to monitor intensity during pregnancy. RPE is more appropriate.
- **Energy intake**: pregnant and breastfeeding women need to consume extra calories. The recommended energy intake varies according to the woman and her stage of pregnancy but is something that must be considered.
- **Relaxin**: the concentration of the hormone relaxin is increased during pregnancy and for some time afterwards. Higher levels of relaxin make a woman’s joints ‘looser’ putting her more at risk of injury from overstretches or sudden changes in direction.
- **Re-starting exercise postpartum**: after a normal vaginal delivery, most women will be able to begin exercising after four to six weeks postpartum. It is always recommended, however, that women obtain clearance from their healthcare professional before restarting an exercise programme.
Programming guidelines

The American College of Obstetricians and Gynaecologists guidelines for exercise for pregnant women with no complications (Artal and O’Toole, 2003) are outlined in table 8.2. It is important that the woman’s capabilities and any symptoms or discomforts are closely monitored during her pregnancy and the activity programme adjusted accordingly. The appropriateness of the exercise alongside the woman’s safety and that of her baby must be of the utmost consideration.

Table 8.2 Summary of ACSM ante and postnatal exercise guidelines.

<table>
<thead>
<tr>
<th>Training variable</th>
<th>CV training</th>
<th>Resistance training</th>
<th>Flexibility training</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>At least three days a week.</td>
<td>At least two days a week.</td>
<td>At least two days a week.</td>
</tr>
<tr>
<td></td>
<td>Preferably every day.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intensity</td>
<td>Moderate intensity.</td>
<td>Moderate intensity.</td>
<td>To achieve normal ROM.</td>
</tr>
<tr>
<td></td>
<td>Twelve to 14 RPE on Borg scale.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time</td>
<td>Up to 30 minutes a day.</td>
<td>Perform exercises for all major muscle groups.</td>
<td>Perform at least one stretch for all major muscle groups.</td>
</tr>
<tr>
<td></td>
<td>Total of 150 minutes a week.</td>
<td>Complete approximately 12 to 15 repetitions.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Beware of thermoregulation if exercising for more than 45 minutes.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type</td>
<td>Dynamic, rhythmic activities that use large muscle groups; for example, walking, cycling and swimming.</td>
<td>Avoid supine exercise, isometric actions and Valsalva manoeuvre.</td>
<td>Avoid supine exercise.</td>
</tr>
</tbody>
</table>
Physical activity levels have been shown to decline markedly as children approach adolescence. It is important to try to reverse this trend as people who are active as children are more likely to continue exercising as adults. In addition, young people who are active are less likely to be overweight: this will help to protect them against certain conditions such as diabetes and cardiovascular disease in youth and adulthood.

General considerations

It is important to remember that young people are not ‘mini-adults’ and that their skeletal, muscular and cardiovascular systems are immature. Some of the general considerations that need to be taken into account when programming for this group include:

- **Supervision**: young people require a higher level of attention and supervision during an exercise programme than adults to ensure that their technique is correct and that they are not doing themselves any ‘harm’.
- **Technique not weight**: with young people it is recommended to focus on technique rather than the amount of weight lifted.
- **Developing skeleton**: care must be taken when working with young people as their skeletons are still developing. A well-developed, supervised exercise programme will not cause any growth defects and will help to boost peak bone mineral density.
- **Hydration**: the thermoregulatory system of young people is immature and they need to pay special attention to their hydration status during exercise. Where possible, they should exercise in a ‘thermoneutral’ environment.

Programming guidelines

The ACSM (2010) guidelines for exercise prescription for young people are outlined in table 8.3.

<table>
<thead>
<tr>
<th>Training variable</th>
<th>CV training</th>
<th>Resistance training</th>
<th>Flexibility training</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>At least three to four days a week. Ideally, every day.</td>
<td>Two to three days a week on non-consecutive days.</td>
<td>At least two days a week.</td>
</tr>
<tr>
<td>Intensity</td>
<td>Moderate to vigorous intensity.</td>
<td>Low to moderate intensity.</td>
<td>Moderate.</td>
</tr>
<tr>
<td>Time</td>
<td>Aim for 30 minutes of moderate and 30 minutes of vigorous daily. Inactive / overweight individuals may slowly progress to 60 minutes.</td>
<td>Perform exercises for all major muscle groups. Complete approximately eight to 15 repetitions.</td>
<td>Perform at least one stretch for all major muscles groups.</td>
</tr>
<tr>
<td>Type</td>
<td>Any activity that uses major muscle groups; for example, cycling, football, dance, tennis, walking, circuits.</td>
<td>Bodyweight exercises or circuit based training sessions are ideal. Any RT as long as it is well-performed and supervised.</td>
<td>Developmental stretching for all major muscle groups.</td>
</tr>
</tbody>
</table>
Working with disabled people

The term ‘disabled’ incorporates a wide range of conditions and it is impossible to be an expert in them all. It is important, however, that fitness professionals are able to work with disabled people in order to help them benefit from improved fitness. In many cases, disabled people themselves will be the ‘experts’ and they will know their own capabilities. This being the case, the fitness professional will simply need to elicit this information and translate it to a balanced exercise programme.

General considerations

Some general considerations to be taken into account when programming for this group include:

- **Safety**: any activity prescribed for disabled people must be safe for them to perform. The relative safety of the activity will depend upon the disability of the person; for example, a blind person may have difficulty using a treadmill but be fine on a stationary bike.
- **Suitability of exercises**: the nature of a person’s disability will determine the suitability of an exercise. Factors to consider include the person’s physical capability, mental capability and sensory capability.
- **Equipment modifications**: some equipment can be modified and adapted to be made suitable for certain disabled users. If this is the case, it is important that fitness professionals are aware of how to make these modifications and for whom the equipment is suitable.
- **Respect differences**: one of the most important considerations when working with disabled people is to ensure that the focus is placed on the ‘can do’ not on the ‘cannot do’. By concentrating on the capabilities of the disabled person, it encourages participation and inclusion.
- **Medication**: some disabled people will be taking prescription medicine for their condition. If this is the case it is important that they have medical clearance as there are contraindications for exercise associated with certain medications.
- **Take advice**: in some cases it may be necessary to consult people’s medical professional or carer, if they have one. If this becomes necessary, the disabled people’s consent should be gained before speaking to anyone else about them or their programme.
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Learning activity 8.2
In your own words, describe the ways in which you would need to adapt a programme for each of the following special populations:

<table>
<thead>
<tr>
<th>Special population</th>
<th>Programme adaptations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Older people</td>
<td>• the intensity of the exercise undertaken</td>
</tr>
<tr>
<td></td>
<td>• any medication they are taking</td>
</tr>
<tr>
<td></td>
<td>• their confidence level, and</td>
</tr>
<tr>
<td></td>
<td>• their ability to balance.</td>
</tr>
<tr>
<td>Ante and postnatal women</td>
<td>• whether they need to consult a medical professional before beginning exercise</td>
</tr>
<tr>
<td></td>
<td>• how their balance and posture have been affected by the pregnancy</td>
</tr>
<tr>
<td></td>
<td>• how to maintain their hydration status</td>
</tr>
<tr>
<td></td>
<td>• ways to avoid exercise in the supine position and the manoeuvre</td>
</tr>
<tr>
<td></td>
<td>• the fact that they require an increased energy intake</td>
</tr>
<tr>
<td></td>
<td>• the fact that they have a higher concentration of the hormone relaxin, and</td>
</tr>
<tr>
<td></td>
<td>• how long ago they gave birth and whether they have had medical clearance to start exercising.</td>
</tr>
<tr>
<td>Young people</td>
<td>• the impact of the exercise on their developing skeleton</td>
</tr>
<tr>
<td></td>
<td>• whether they need supervision, and</td>
</tr>
<tr>
<td></td>
<td>• how to maintain the focus on technique not intensity.</td>
</tr>
<tr>
<td>Disabled people</td>
<td>• whether the exercise is safe and suitable for them</td>
</tr>
<tr>
<td></td>
<td>• whether equipment can be modified to help make exercises more appropriate</td>
</tr>
<tr>
<td></td>
<td>• any medication that they are taking, and</td>
</tr>
<tr>
<td></td>
<td>• whether they need medical clearance to take part in exercise.</td>
</tr>
</tbody>
</table>

Summary
You should now know that:

- when working with older people it is important to consider:
  - the intensity of the exercise undertaken
  - any medication they are taking
  - their confidence level, and
  - their ability to balance.

- when working with antenatal and postnatal women it is important to consider:
  - whether they need to consult a medical professional before beginning exercise
  - how their balance and posture have been affected by the pregnancy
  - how to maintain their hydration status
  - ways to avoid exercise in the supine position and the manoeuvre
  - the fact that they require an increased energy intake
  - the fact that they have a higher concentration of the hormone relaxin, and
  - how long ago they gave birth and whether they have had medical clearance to start exercising.

- when working with young people it is important to consider:
  - the impact of the exercise on their developing skeleton
  - whether they need supervision, and
  - how to maintain the focus on technique not intensity.

- when working with disabled people it is important to consider:
  - whether the exercise is safe and suitable for them
  - whether equipment can be modified to help make exercises more appropriate
  - any medication that they are taking, and
  - whether they need medical clearance to take part in exercise.
Understanding professional boundaries

As has already been stated in the section on special populations, all professionals have ‘boundaries’ or limits to their skills and knowledge. These boundaries relate to the training that the professionals have received and the experience that they have gained. It is important that professionals in all fields work within their professional boundaries, to ensure that they do not risk giving incorrect advice or practising beyond their skill and knowledge level. Professionals who act outside of their boundaries could risk someone taking legal action against them.

Fitness professionals have access to a range of qualifications that can allow them to practise with different specialisms. Fitness professionals who do not hold a nutrition qualification are advised to avoid giving specific dietary guidance. Instead they should refer anyone requiring such advice to a relevantly qualified professional.

People requiring nutritional advice could be referred to one of the following:

- Their GP: a GP referral is vital if a person has a medical condition requiring nutritional intervention.
- A State Registered Dietician (SRD): SRDs have relevant degrees and practical experience which allow them to deliver specific dietary interventions in clinical settings.
- An appropriately qualified fitness professional: fitness professionals with nutrition qualifications may be able to provide support and guidance for people who require basic dietary intervention. Further referral to a GP or SRD may be required.
The eatwell plate

A healthy diet is a balanced diet but understanding the required balance can be confusing. The eatwell plate model was developed to help make healthy eating easier to understand. The eatwell plate (figure 9.1) shows the types and proportions of foods people need to consume to achieve a healthy, well balanced diet.

Learning activity 9.1

Label each of the five food groups on the diagram below:

Figure 9.1 The eatwell plate (© crown copyright, reproduced with the permission of the Controller of HMSO and Queen’s Printer for Scotland).

Each of the five main food groups is designated a coloured segment on the eatwell plate. The segments and their related food groups are:

- yellow: bread, rice, potatoes, pasta and other starchy foods
- green: fruit and vegetables
- blue: milk and dairy foods
- pink: meat, fish, eggs, beans and other non-dairy sources of protein, and
- purple: foods and drinks that are high in fat and / or sugar.

The eatwell plate illustrates that the majority of a person’s dietary intake should come from the starchy foods and fruit and vegetables groups. Each of these groups should make up approximately one third of a person’s dietary intake. The remaining third of the diet should be made up of equal amounts of foods from the two protein groups (dairy and non-diary) and a limited amount of high fat and / or sugar food and drinks.

The eatwell plate suggests a balance suitable for most people including those who are a healthy weight, those who are overweight, those who follow vegetarian diets and those who follow different cultural diets. It is not suitable, however, for children below two years of age. In addition, anyone who is following a special diet under the care of a medical professional or dietician may need to check whether the eatwell plate is an appropriate model for them.
Healthy eating

In order to maintain a healthy diet an individual should try to achieve the balance shown in the eatwell plate. It is also important, however, to keep salt intake to a minimum, consume at least five portions of fruit and vegetables every day and limit intake of saturated fat and sugar.

Salt intake

Adults in the UK are recommended to eat less than 6g of salt per day (equivalent to 2.4g sodium) but the majority consume much more. An excessive salt intake can increase blood pressure which can, in turn, increase the risk of heart disease and stroke. The good news is that a reduction in salt intake will reduce blood pressure even if it is not categorised as clinically ‘high’. As a result, the risk of co-morbidities also decreases. A person with high blood pressure could lower this within four weeks through a reduction in salt intake. Unfortunately, salt intake cannot be reduced simply by not adding salt to food as approximately 75% of dietary salt intake comes from within the food itself. To reduce salt intake a person needs to become a little more aware of the type of products and foods that are high in salt including:

- bread
- breakfast cereals
- ready meals, and
- ready-made sauces; for example, pasta sauces and ketchup.

Five-a-day

Most people in the UK have heard of the five-a-day campaign which aims to get everybody to eat at least five, 80g portions of fruit and vegetables, on a daily basis. The majority of adults, however, still consume fewer than the recommended amount. This could be detrimental to their health. The five-a-day target is based upon World Health Organisation recommendations which state that in order to glean the health benefits from fruit and vegetables adults should eat at least 400g of these foods every day. The eatwell model illustrates that fruit and vegetables should make up a third of a person’s daily dietary intake but aiming for five-a-day makes an easier target. There are many reasons for this recommendation including:

- a large body of evidence shows that diets high in fruit and vegetables reduce the risk of heart disease, stroke, type 2 diabetes, obesity and certain cancers
- fruit and vegetables are a good source of dietary fibre and diets that are high in fibre may help to reduce the incidence of bowel cancer
- fruit and vegetables are an excellent source of vitamins and minerals
- compared to other foods, fruit and vegetables are low in fat, and
- fresh fruit and vegetables have a low calorie-density.

When consuming the recommended five-a-day, people are advised to eat a variety of different fruit and vegetables as they all contain different combinations of fibre, vitamins and minerals. All fruit and vegetables count towards the five-a-day target apart from potatoes, which are classed as starchy carbohydrates.

Many people think that fruit and vegetable intake has to come from fresh produce but the following forms also counts towards the five-a-day:
- frozen
- dried
- tinned or canned, and
- juices or smoothies.

For more information see [www.5aday.nhs.uk](http://www.5aday.nhs.uk)
Saturated fat intake

Fat is an essential part of a balanced healthy diet but excessive fat intake can be damaging to a person’s health. Although fat provides the body with vitamins A, D, E and K, it has a high-energy density and is likely to be high in calories, which can increase the risk of obesity.

There are different types of dietary fat and these can be simply categorised as saturated or unsaturated fats. Of particular concern to health is a person’s intake of saturated fat. Saturated fat in high concentrations is mainly found in animal-sources of food; for example, meat and dairy products.

<table>
<thead>
<tr>
<th>COMMON SOURCES OF DIETARY FAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meat, particularly fatty cuts of meat</td>
</tr>
<tr>
<td>Meat products; for example, sausages and burgers</td>
</tr>
<tr>
<td>Full-fat dairy products; for example, cheese, cream, yoghurt and ice cream</td>
</tr>
<tr>
<td>Butter, lard and ghee</td>
</tr>
<tr>
<td>Pastry-based products; for example, quiche, pies, pastries, sweet pastries</td>
</tr>
<tr>
<td>Cakes and biscuits</td>
</tr>
<tr>
<td>Pre-prepared ‘ready’ meals</td>
</tr>
<tr>
<td>Coconut and palm oil</td>
</tr>
</tbody>
</table>

It is recommended that men consume less than 30g of saturated fat per day and women less than 20g per day but, on average, people consume approximately 20% above this level. This excessive intake can be damaging to health because diets high in saturated fat can raise blood cholesterol level. High blood cholesterol is directly linked to risk of coronary heart disease (CHD) so a diet high in fat increases the risk of CHD.

Most people in the UK need to lower their intake of saturated fat in order to lower their risk of CHD. Some simple changes which will bring about a reduction in saturated fat include: swapping from full-fat dairy products to low-fat, substituting regular minced beef for lean minced beef, switching from butter to low-fat spread, using skimmed milk in cooking, cutting any visible fat off meat and grilling foods instead of frying them.

Sugar intake

Sugar occurs naturally in many foods such as milk and fruit but it is also added to many products. In terms of health it is the added sugars that are of concern not those that are naturally occurring. Foods that are high in added sugar such as sweets, fizzy drinks, biscuits and cakes should be eaten in limited amounts. Most people do consume too much of these items and it is potentially bad for their health.

It is a myth that excess sugar in the diet directly causes conditions such as diabetes. In reality, it is the excess calories consumed that lead to weight gain which, in turn, leads to conditions such as heart disease, high blood pressure and type 2 diabetes. Excessive sugar intake can also cause tooth decay.

The problem with sugary foods is that they taste good and people want to eat a lot of them. The desire to eat sugary foods is compounded by the fact that an increasing number and variety are available on the market: products such as sports drinks, fizzy drinks, sugary cereals, fruit juices, smoothies and chocolate bars have proliferated in the past 20 years. This increase in availability has led to a rise in consumption which, in turn, has led to a growth in the health problems associated with excess weight. The severity of this problem led the World Health Organisation to release guidelines regarding sugar intake.

It is recommended that less than 10% of daily energy intake comes from sugar.

- 10% of a 2,000 calorie diet = 200 calories
- One teaspoon of sugar = 25 calories
- 200 divided by 25 = 8

Thus someone consuming 2,000 calories a day should eat no more than 8 teaspoons of sugar per day.

The following table (table 9.1) illustrates the sugar content of some commonly consumed food and drinks.

<table>
<thead>
<tr>
<th>Food / drink</th>
<th>Sugar content</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 can Coca-Cola</td>
<td>10 teaspoons</td>
</tr>
<tr>
<td>1 Snickers bar</td>
<td>6 teaspoons</td>
</tr>
<tr>
<td>200ml low-fat fruit yoghurt</td>
<td>7 teaspoons</td>
</tr>
</tbody>
</table>
Table 9.1 (continued)

<table>
<thead>
<tr>
<th>Food / drink</th>
<th>Sugar content</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 tablespoon ketchup</td>
<td>1 teaspoon</td>
</tr>
<tr>
<td>1 serving Quaker Oat Granola</td>
<td>4.5 teaspoons</td>
</tr>
<tr>
<td>1 slice white bread</td>
<td>3 teaspoons</td>
</tr>
<tr>
<td>1 Fruit and Fibre cereal bar</td>
<td>2.5 teaspoons</td>
</tr>
</tbody>
</table>

Learning activity 9.2

Using the table below, describe how following the recommended guidelines for each dietary factor can benefit health:

<table>
<thead>
<tr>
<th>Dietary factor</th>
<th>Health benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limiting salt intake</td>
<td></td>
</tr>
<tr>
<td>Eating five-a-day fruit and vegetables</td>
<td></td>
</tr>
<tr>
<td>Limiting saturated fat intake</td>
<td></td>
</tr>
<tr>
<td>Limiting sugar intake</td>
<td></td>
</tr>
</tbody>
</table>

Hydration

Around two thirds of the human body is made up of water and it is important to maintain this volume. Adequate hydration is required for the correct physiological functioning of many processes in the body; for example, regulating body temperature, maintaining blood volume, lubricating joints and eyes, transporting nutrients around the body and removing waste products from the body.

A lack of water in the body is referred to as dehydration. This can affect a person’s health and may cause headaches, fatigue, tiredness, dizziness, blurred vision, confusion and poor physical and mental performance. As water is constantly lost from the body through the processes of sweating, breathing and removal of waste products, it is important that it is replaced with fluid from the diet.

The average UK adult requires between one and two litres of fluid per day which equates to six to eight glasses of water or fluid per day. Those in a hot environment or who are taking part in physical activity require an even greater fluid intake. Regular fluid consumption throughout the day is recommended in order to maintain adequate fluid intake. It is not sufficient to drink only when the feeling of thirst is experienced. This is a very poor indicator of hydration as once a person is thirsty they are already dehydrated.

In terms of physical performance, just a small fall in hydration can lead to a significant decrease in physical capability. In fact, a 2 % drop in body water can lead to a 5 % drop in exercise ability whereas a 5 % loss in body water may cause a 30 % decrease in performance. It is important, therefore, that people who are exercising maintain adequate hydration levels by drinking regularly before and during their session.

Learning activity 9.3

List three reasons as to why it is important to stay hydrated:

1. 
2. 
3. 
Macro-nutrients: roles and dietary sources

Macro-nutrients are those nutrients that are needed by the body in large amounts. The macro-nutrients are carbohydrate, fat and protein.

Carbohydrate is the body’s main fuel and it is the only energy source that can be used by the brain. It is important that the diet contains adequate carbohydrate. If it does not, a greater percentage of dietary protein will be used as a fuel, meaning that less is available for the growth and repair of the body’s tissues. Carbohydrate is said to have a ‘protein-sparing effect’.

Dietary carbohydrate can be split into two groups – starchy carbohydrates and sugary carbohydrates. Some of the common dietary sources of carbohydrate are shown in table 9.2. One gram of carbohydrate, whatever the source, provides approximately four calories and a healthy diet should provide at least 50% of its energy from carbohydrate. Starchy carbohydrate provides fibre and other nutrients whereas sugary carbohydrate provides little else apart from energy. The majority of carbohydrate in the diet should, therefore, come from whole grain starchy sources.

Fat has many roles in the body. It is used as an energy source, for insulation and for cushioning and protection of the vital organs. In addition, fat acts as a carrier of the fat-soluble vitamins A, D, E and K and it is integral to cell membrane structure. Fat is also vital to nerve transmission as the myelin sheath is 70% fat.

Fats are classified according to their structure and, most simply, they can be categorised as saturated or unsaturated fats. Whatever the type of fat, one gram contains approximately nine calories, making it the most energy dense nutrient. In terms of a healthy diet, excess saturated fat is closely related to an increase in a person’s health risks whereas unsaturated fat is known as ‘healthy fat’ as it can help to protect against heart disease. Good sources of the different types of fat are shown in table 9.2. A healthy diet should contain limited amounts of fat and saturated fat should account for less than 11% of energy consumption.

Protein is important in the diet for the growth and repair of body tissues. Proteins are made up of amino acids which are known as the ‘building blocks’ of proteins. Amino acids are classified as ‘essential’ or ‘non-essential’ according to whether or not they can be synthesised within the body. There are eight essential amino acids which cannot be synthesised by the body and, therefore, have to be consumed in the diet. Protein sources can be categorised according to the number of amino acids that they contain. ‘Complete’ proteins contain all eight of the essential amino acids whereas ‘incomplete’ proteins are lacking in one or more of the essential amino acids.

All proteins, regardless of their source contain approximately four calories per gram. Good dietary sources of protein are shown in table 9.2. A healthy diet contains between 10% and 20% protein but care needs to be taken as high-protein foods are often high in fat or cooked in ways that increase their fat content.

<table>
<thead>
<tr>
<th>Carbohydrate</th>
<th>Fat</th>
<th>Protein</th>
</tr>
</thead>
<tbody>
<tr>
<td>Starchy carbohydrate</td>
<td>Saturated</td>
<td>Unsaturated</td>
</tr>
<tr>
<td>Bread</td>
<td>Sugar</td>
<td>Butter</td>
</tr>
<tr>
<td>Pasta</td>
<td>Honey</td>
<td>Lard</td>
</tr>
<tr>
<td>Rice</td>
<td>Jam</td>
<td>Fat on meat</td>
</tr>
<tr>
<td>Potatoes</td>
<td>Sweets</td>
<td>Coconut / palm oil</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 9.2 Dietary sources of macronutrients
Micro-nutrients: roles and dietary sources

Vitamins and minerals are known as micro-nutrients as they are needed by the body in small, or sometimes, tiny amounts. Each micro-nutrient has its own recommended daily intake (RDI) with some being required in larger amounts than others. The micro-nutrients are essential for the correct physiological functioning of the body as they are involved in a multitude of processes within the body from bone health to blood cell growth, energy metabolism to immune system function.

**Vitamins** are classified as water-soluble or fat-soluble. Fat-soluble vitamins (A, D, E and K) can be stored within the fatty tissues of the body, whereas the water-soluble vitamins (B vitamins and C) cannot be stored and excess intake of these vitamins will be excreted in the urine. The only vitamin that can be synthesised by the body is vitamin D, through the action of sunlight on the skin. Vitamins A, C and E are important for a healthy immune system, the B vitamins are required for energy metabolism, vitamin D is important for bone health and vitamin K is involved in blood clotting.

**Minerals** are inorganic substances which are required for many different roles in the body. Some minerals are needed in much larger amounts than others and, for this reason, they can be categorised as major minerals or trace minerals. The use of minerals within the body is varied; for example, iron is vital for red blood cell formation, calcium is needed for bone health, sodium is necessary for regulating body water content and zinc is involved in metabolism.

Vitamins and minerals are found in high concentrations in a variety of foods but fruit and vegetables tend to be an excellent source. More specifically some of the common sources of some micro-nutrients are as follows:

- **Vitamin A:** whole milk, cheese, butter, liver, carrots, dark green leafy vegetables, apricots.
- **Vitamin D:** oily fish, fortified cereals, margarine.
- **Vitamin E:** vegetable oils, seed and nut oils, seeds, nuts.
- **Vitamin K:** dairy products, green leafy vegetables.
- **B vitamins:** meat, nuts, whole grains, yeast, milk, eggs, dairy products, liver, green vegetables.
- **Vitamin C:** citrus fruits, berries, green vegetables, peppers, tomatoes, new potatoes.
- **Iron:** liver, red meat, pulses, nuts, eggs, dried fruit, fish, poultry, whole grains, dark green leafy vegetables.

(continues overleaf)
Learning activity 9.5
Identify some of the common food sources for the following nutrients:

Carbohydrate

Fat

Protein

B Vitamins

Vitamin C

Calcium

Iron

Energy balance

In order to maintain current body weight people need to be in 'energy balance'. This means that energy intake (EI) and energy expenditure (EE) need to be equal. EI is the energy that is consumed through diet and EE is the sum of the energy used to keep the body functioning and that needed for daily activity. Energy balance is shown graphically in figure 9.2 below.

Figure 9.2 Energy balance.

Energy balance can also be shown as an equation:

Energy balance occurs when

energy intake = energy expenditure

If a person’s EI and EE do not balance, that person is said to be in either positive or negative energy balance. Positive energy balance occurs when people consume more calories than they need. Those in positive energy balance for a period of time will experience a gain in their body mass. Figure 9.3 shows how positive energy balance is achieved.
Learning activity 9.6

Finish the following sentences:

1. If energy intake = energy expenditure, a person is in

2. If energy intake is greater than energy expenditure, a person is in

3. If energy intake is less than energy expenditure, a person is in

Missing words: positive energy balance, energy balance, negative energy balance.
Nutrition and health

Dietary intake is closely related to health: an imbalance in nutrient intake or a lack of certain nutrients can lead to an increased risk of certain conditions and sub-optimal health. This is why a healthy diet is a balanced diet. The following list outlines some of the risks associated with poor nutrition:

- Lack of carbohydrate: fatigue, lack of energy, poor concentration, dizziness, poor physical and mental performance.
- Excess sodium intake: high blood pressure.
- Lack of vitamins and minerals: weak immune system, anaemia, poor bone health.
- Excess calorie intake: obesity and its associated conditions such as type 2 diabetes, high blood pressure and CHD.
- Excess fat intake: hypercholesterolemia, CHD, obesity and its associated conditions.

Summary

You should now know that fitness professionals must remember their professional boundaries. Nutrition is a specialist area and fitness professionals who operate outside of their professional boundaries in respect of this discipline could ‘cause harm’ to a person for whom they are responsible.

You should now know that the eatwell plate is the national food model/guide. It shows the types and proportions of foods that people need to eat in order to achieve a healthy, well balanced diet.

You should now know that a healthy diet optimises a person’s health. There are some key dietary factors that will affect a person’s health:

- their salt intake
- their fruit and vegetable intake
- their saturated fat intake, and
- their sugar intake.

You should now know that adequate hydration will have a beneficial effect on the human body. Poor hydration can result in a number of problems including:

- suboptimal mental and physical performance
- poor temperature regulation
- reduced blood volume, and
- headaches, fatigue, tiredness, dizziness, blurred vision, confusion.

You should now know that the key nutrients in the diet are:

- carbohydrate
- protein
- fat
- vitamins, and
- minerals.

You should now understand how the energy balance equation and how this explains weight loss or weight gain:

- Energy balance occurs when energy intake = energy expenditure
- Positive energy balance occurs when energy intake > energy expenditure
- Negative energy balance occurs when energy intake < energy expenditure

You should now know that poor nutrition can lead to poor health due to an imbalanced intake of nutrients.
Section 10: Learning Activity answers

Section 1: Physical activity and health

Learning activity 1.1
1. By lowering their blood pressure.
2. By improving their cholesterol profile.
3. By helping them maintain a healthy weight.

Learning activity 1.2
1. Colon cancer.
2. Breast cancer.

Learning activity 1.3
Regular physical activity can help to lower a person’s risk of type 2 diabetes both directly and indirectly. Directly, it helps to prevent the development of insulin sensitivity and insulin resistance. Indirectly, it helps the maintenance of a healthy body weight and a healthy visceral fat level which, in turn, lowers the risk of type 2 diabetes.

Learning activity 1.4
No correct answer.

Learning activity 1.5
Weight-bearing physical activity can help to lower a person’s risk of osteoporosis by stimulating the osteoblasts to increase BMD. This strengthens the bone that is stressed by the physical activity.
Section 2: The components of fitness

Learning activity 2.1
Names and healthy characteristics (example answers):
1. My brother. He plays a lot of sport.
2. My mum. She eats very healthy food and walks a lot.
3. My friend Jack. He works out at the gym and eats very carefully.
4. My dad. He’s never had a day off work sick in his life.

Common characteristics identified: fitness, eating habits, absence of illness.

Learning activity 2.2
1. CV fitness: being able to run for the bus.
2. Muscular strength: being able to lift a heavy box up onto a high shelf.
3. Muscular endurance: being able to sweep a floor.
4. Flexibility: being able to bend down and tie your shoe laces.
5. Body composition: not being overweight so not getting out of breath too easily.

Learning activity 2.3

<table>
<thead>
<tr>
<th>Motor-skill</th>
<th>Use in daily life</th>
<th>Use in sport</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed</td>
<td>Sprinting to catch a bus.</td>
<td>A sprint finish at the end of a marathon.</td>
</tr>
<tr>
<td>Quickness</td>
<td>Catching something that has been knocked over before it hits the floor.</td>
<td>Catching a ball that is hit towards to you; for example, a goalkeeper or wicket keeper.</td>
</tr>
<tr>
<td>Agility</td>
<td>Moving out of the way quickly; for example, if a bike comes towards you on a pavement.</td>
<td>Dribbling around an opponent in football.</td>
</tr>
<tr>
<td>Balance</td>
<td>Standing on a step ladder.</td>
<td>Balancing on a beam in gymnastics.</td>
</tr>
<tr>
<td>Co-ordination</td>
<td>Pouring water into a glass.</td>
<td>Dancing.</td>
</tr>
<tr>
<td>Power</td>
<td>Pushing a heavy door open.</td>
<td>Kicking a rugby ball.</td>
</tr>
</tbody>
</table>

Learning activity 2.4

<table>
<thead>
<tr>
<th>Modifiable factors</th>
<th>Non-modifiable factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current training status</td>
<td>Genetics</td>
</tr>
<tr>
<td>Nutritional status</td>
<td>Age</td>
</tr>
<tr>
<td>Recovery / sleep</td>
<td>Gender</td>
</tr>
<tr>
<td>Lifestyle</td>
<td>Training history</td>
</tr>
<tr>
<td></td>
<td>Medical history</td>
</tr>
</tbody>
</table>

Learning activity 2.5
Genetics, training history, current training status, nutritional status, recovery, medical history.
Section 3: Effects of cardiovascular training on the body

Learning activity 3.1

- Increased stroke volume and cardiac output
- Improved blood profile
- Decreased RHR
- Decreased submaximal HR
- Increased maximal oxygen uptake
- Improved oxygen extraction from blood
- Increased heart size
- Adaptions to CV training
- Increased minute ventilation

Learning activity 3.2

<table>
<thead>
<tr>
<th>Situation</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systolic BP during a submaximal run</td>
<td>↑</td>
</tr>
<tr>
<td>Systolic BP when doing a set of squats</td>
<td>↑</td>
</tr>
<tr>
<td>Systolic BP at rest after a 12 week CV training programme</td>
<td>↓</td>
</tr>
<tr>
<td>Diastolic BP during a graded exercise test</td>
<td>↔ / ↓</td>
</tr>
<tr>
<td>Diastolic BP at rest after 12 week cycling training prog.</td>
<td>↓</td>
</tr>
</tbody>
</table>

Learning activity 3.3

During rhythmical exercise which involves the legs, the calf muscles act as ‘pumps’, squeezing blood in the veins back towards the heart. A sudden cessation in exercise means that this ‘muscle pump’ action stops abruptly and this can lead to the ‘pooling’ of blood in the legs as the heart will continue to beat at a faster than resting rate for a few minutes. This pooling means that the blood and any waste products contained within it build up in the calf muscles which can lead to pain and swelling in the lower limbs. Due to the accumulation of blood in the lower limbs, individuals can also sometimes experience a drop in their blood pressure alongside symptoms such as dizziness and fainting.

Learning activity 3.4

- Stationary bike
- Cross trainer
- Treadmill (running)
- Stepper
- Rowing machine

Learning activity 3.5

Endurance training makes muscles fitter. Muscles that have undergone endurance training will become tired more slowly than those which have not been trained.

Adaptions to CV training

- Decreased RHR
- Increased minute ventilation
- Increased maximal oxygen uptake
- Improved oxygen extraction from blood
- Increased heart size
- Improved blood profile
- Decreased submaximal HR

Endurance training makes muscles fitter. Muscles that have undergone endurance training will become tired more slowly than those which have not been trained.

- Stationary bike
- Cross trainer
- Treadmill (running)
- Stepper
- Rowing machine
Workbook

Level 2
Principles of Exercise, Fitness and Health

Section 4:
Effects of resistance training on the body

Learning activity 4.1
This should look like figure 4.1.

Learning activity 4.2

<table>
<thead>
<tr>
<th>Adaptation</th>
<th>Type of training</th>
<th>Muscular endurance</th>
<th>Hypertrophy</th>
<th>Muscular strength</th>
<th>Short-term or long-term</th>
</tr>
</thead>
<tbody>
<tr>
<td>size of type 1 and type 2 fibres</td>
<td></td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>neural fatigue</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>enzyme activity</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>blood flow to muscles</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>number of mitochondria</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>intramuscular lactic acid</td>
<td></td>
<td>✓</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>maximal strength</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>improved neuromuscular communication</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>breakdown of glucose and fatty acids to produce energy</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>energy stores within muscles</td>
<td></td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

Learning activity 4.3

Delayed onset muscle soreness (DOMS) is a phenomenon that typically occurs 24 to 72 hours after resistance training although it has been reported that this can continue to be experienced for up to nine days after training.

DOMS is characterised as a dull, aching type pain experienced in muscles after unaccustomed or strenuous exercise, which may be accompanied by stiffness. It is tender when pressure is applied to affected muscles. The pain and sensitivity is caused by micro-trauma to muscle fibres and the subsequent inflammatory response.

DOMS is part of the normal repair process of muscle and is thought to be an essential in order for hypertrophy to occur. Although any unaccustomed exercise can cause DOMS, certain types of exercise are strongly associated with it. Eccentric or negative contractions (the lowering phase of an exercise) and high impact exercises or jumping exercises such as plyometrics which have intense eccentric loading phases cause the worst DOMS.
Section 5: Effects of flexibility training on the body

Learning activity 5.1

Short-term: there is an increase in ROM which lasts about 30 minutes. There is also an increase in the sarcomere length and a decreased overlap between the actin and myosin filaments. The activity of the motor neurons that innervate the stretched muscles is decreased.

Long-term: ROM increases as does the resting muscle length. There is a reduction in muscle tightness and an increase in the number of sarcomeres at the end of the muscle. The stretch receptors become trained meaning that the muscles can lengthen more before they fire.

Section 6: Monitoring exercise intensity

Learning activity 6.1

<table>
<thead>
<tr>
<th>Method</th>
<th>Benefits</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Talk test</td>
<td>Simple way to monitor intensity</td>
<td>Limited feedback about intensity</td>
</tr>
<tr>
<td></td>
<td>No equipment needed</td>
<td>Limited use for interval training</td>
</tr>
<tr>
<td></td>
<td>Can be used across exercise modes</td>
<td>Subjective</td>
</tr>
<tr>
<td></td>
<td>Accurately identifies VT</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Suitable for most people</td>
<td></td>
</tr>
<tr>
<td>RPE</td>
<td>Easy to use</td>
<td>Subjective</td>
</tr>
<tr>
<td></td>
<td>Little equipment needed</td>
<td>Scale can be hard to use</td>
</tr>
<tr>
<td></td>
<td>Can be used with HR</td>
<td>Novices find it more difficult to use</td>
</tr>
<tr>
<td></td>
<td>Suitable for most people</td>
<td></td>
</tr>
<tr>
<td>Heart rate monitoring</td>
<td>Objective</td>
<td>Not suitable with certain medication</td>
</tr>
<tr>
<td></td>
<td>Accurate</td>
<td>Need HR monitoring equipment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Exerciser needs to wear a monitor</td>
</tr>
</tbody>
</table>
Learning activity 6.2

\[ HR_{\text{max}} = 220 - \text{age} \]
\[ = 220 - 35 \]
\[ = 185 \text{bpm} \]

John’s \( HR_{\text{max}} \) is estimated as 185bpm

\[ \%HR_{\text{max}} = \frac{HR_{\text{max}} \times \text{desired } \%}{100} \]
\[ = \frac{(185 \times 75)}{100} \]
\[ = 138.75 \text{bpm} \]

John would work at 139bpm to achieve 75% \( HR_{\text{max}} \)

Learning activity 6.3

\[ \text{HRR} = HR_{\text{max}} - \text{RHR} \]
\[ = 185 - 60 \]
\[ = 125 \text{bpm} \]

John’s HRR is estimated as 125bpm

\[ \% \text{HRR} = \frac{(\text{HRR} \times \text{desired } \%)}{100} + \text{RHR} \]
\[ = \frac{(125 \times 75)}{100} + 60 \]
\[ = 93.75 + 60 \]
\[ = 153.75 \text{bpm} \]

John would work at 154bpm to achieve 75% \( HR_{\text{max}} \)
using the HRR method

Section 7:
Principles of programme design

Learning activity 7.1

Training adaptations will relate to the type of training that is performed: specificity.

In order to develop fitness, the body needs to be challenged: overload.

Endurance exercise will mainly develop the long-term energy system: specificity.

If individuals stop training they will start to lose their fitness: reversibility.

After initial overload, further overload needs to be applied in order to improve fitness: progression.

Learning activity 7.2

Frequency: the number of training sessions that are carried out per week.

Intensity: how hard a person works during a training session.

Time: the duration of the training session.

Type: the mode of exercise performed during the session.

Learning activity 7.3

Increase the number of sessions towards three non-consecutive days initially. Once a client is performing this regularly increase up to five sessions of different intensities.

Component of training: cardiovascular fitness
F.I.T.T. variable: frequency

Increase loads when the highest number of repetitions in the desired range can be achieved for two sets in two consecutive sessions. Increase by the smallest available increment.

Component of training: muscular fitness
F.I.T.T. variable: intensity
Section 7: Principles of programme design (continued)

Learning activity 7.3 (continued)

If training for a specific goal, the mode of exercise will be dictated by that goal; for example, marathon = running.
If training for weight loss / general fitness and health a mixture of training modes enjoyed by the participant should be included. Some cross training sessions can be included in all programmes, especially when training on consecutive days to facilitate recovery.

Component of training: cardiovascular fitness
F.I.T.T. variable: type
Ten to 15 seconds is adequate for a maintenance stretch to help return a muscle to its resting length following exercise. Developmental stretches of 30+ seconds performed one to three times at the end of an exercise session can increase muscle length and ROM.

Component of training: flexibility
F.I.T.T. variable: time
Increase the number of sessions towards two full body routines initially, then up to three with at least 24 hours rest between each.

Component of training: muscular fitness
F.I.T.T. variable: frequency

Learning activity 7.4

<table>
<thead>
<tr>
<th>Factor</th>
<th>How it affects exercise intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed of movement</td>
<td>For CV exercise, the faster the movement, the higher the intensity. For RT, it is more complicated as a faster movement can make the exercise easier or harder, depending upon the type of training being performed.</td>
</tr>
<tr>
<td>Lever length</td>
<td>The longer the body lever from the fulcrum, the harder the exercise will be.</td>
</tr>
<tr>
<td>Range of movement</td>
<td>In general, the greater the ROM, the harder the exercise.</td>
</tr>
<tr>
<td>Rest period</td>
<td>Shortening rest periods makes subsequent exercise harder as the muscles will already be tired as they have less time to recover.</td>
</tr>
<tr>
<td>Resistance</td>
<td>The heavier the resistance, the harder the exercise will be</td>
</tr>
</tbody>
</table>
Workbook

Level 2
Principles of Exercise, Fitness and Health

Section 8:
Guidelines for special populations

Learning activity 8.1
1. Providing nutritional advice.
2. Providing advice on safety of exercise with medical conditions.
3. Providing advice on muscular rehabilitation.

Learning activity 8.2

<table>
<thead>
<tr>
<th>Special population</th>
<th>Programme adaptations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Older people</td>
<td>Use lower intensity exercises and progress slowly</td>
</tr>
<tr>
<td></td>
<td>Do not use machines / equipment that require too much balance</td>
</tr>
<tr>
<td></td>
<td>Use activities that do not impose too much orthopaedic stress</td>
</tr>
<tr>
<td></td>
<td>Adapt programme according to any medication they are taking</td>
</tr>
<tr>
<td>Ante and postnatal women</td>
<td>Do not start exercise until received medical clearance</td>
</tr>
<tr>
<td></td>
<td>Avoid supine exercise and Valsalva manoeuvre</td>
</tr>
<tr>
<td></td>
<td>Use RPE not HR</td>
</tr>
<tr>
<td></td>
<td>Do not overstretch</td>
</tr>
<tr>
<td></td>
<td>Moderate intensity</td>
</tr>
<tr>
<td>Young people</td>
<td>Focus on technique, not weight or speed</td>
</tr>
<tr>
<td></td>
<td>Avoid maximal RT exercise</td>
</tr>
<tr>
<td></td>
<td>Stress body weight exercise rather than machines</td>
</tr>
<tr>
<td>Disabled people</td>
<td>Only use exercises that are appropriate to the person's disability</td>
</tr>
<tr>
<td></td>
<td>Modify equipment safely where necessary</td>
</tr>
<tr>
<td></td>
<td>Adapt programmes according to any medication they are taking</td>
</tr>
</tbody>
</table>

Section 9:
Eating for health

Learning activity 9.1

Fruit and vegetables
Bread, rice, potatoes, pasta and other starchy foods
Meat, fish, eggs, beans and other non-dairy sources of protein
Foods and drinks that are high in fat and / or sugar
Milk and dairy foods
Learning activity 9.2

<table>
<thead>
<tr>
<th>Dietary factor</th>
<th>Health benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limiting salt intake</td>
<td>Limiting salt intake reduces the risk of high blood pressure which, in turn, reduces the risk of heart disease and stroke.</td>
</tr>
<tr>
<td>Eating five-a-day fruit and vegetables</td>
<td>Eating adequate fruit and vegetables can help reduce the risk of heart disease, stroke, type 2 diabetes, obesity and certain cancers. Fruit and vegetables are a good source of dietary fibre, which is important to help reduce the incidence of bowel cancer. They also provide high levels of vitamins and minerals and are low in fat which can help with weight control.</td>
</tr>
<tr>
<td>Limiting saturated fat intake</td>
<td>Limiting saturated fat intake can help control blood cholesterol levels. High blood cholesterol is directly linked to risk of coronary heart disease (CHD) so a diet that is high in fat increases the risk of CHD.</td>
</tr>
<tr>
<td>Limiting sugar intake</td>
<td>The extra calories that come from the sugary foods cause health problems as they lead to weight gain. Excess weight can lead to conditions such as heart disease, high blood pressure and type 2 diabetes. Excessive sugar intake can also cause tooth decay.</td>
</tr>
</tbody>
</table>

Learning activity 9.3
1. It helps with temperature regulation.
2. It helps with physical performance.
3. It helps with mental capacity and concentration.

Learning activity 9.4

Carbohydrate is important in the diet as it is the body’s main source of energy and it is the brain’s only fuel source. Adequate carbohydrate in the diet will ensure that protein is not used as an energy source so it can be reserved for growth and repair of bodily tissues.

Fat is important as it is a carrier of vitamins A, D, E and K. It also provides energy for the body and is used for insulation, cushioning and protection of the vital organs. Fat is also an important component of cell membranes and is necessary for optimal nerve transmission.

Protein is vital in the diet as it is used for the growth and repair of the body’s tissues including muscles.

Learning activity 9.5

Carbohydrate: potatoes, bread, rice, pasta, sweets, honey, jam, sugar.

Fat: butter, dairy products, lard, fat on meat, oils, seeds, nuts, avocado.

Protein: meat, fish, poultry, beans, lentils, eggs, soy.

B vitamins: meat, nuts, whole grains, milk, yeast, eggs, dairy products, liver, green vegetables.

Vitamin C: citrus fruits, berries, green vegetables, peppers, tomatoes, new potatoes.

Calcium: dairy products, bread, broccoli, cabbage, fortified products, fish with bones.

Iron: liver, red meat, pulses, nuts, eggs, dried fruit, fish, poultry, whole grains, green leafy vegetables.

Learning activity 9.6

If energy intake = energy expenditure, a person is in energy balance.

If energy intake is greater than energy expenditure, a person is in positive energy balance.

If energy intake is less than energy expenditure, a person is in negative energy balance.


