INQUIRY QUESTION
What does being ‘fit’ mean to you and what affects your fitness?
The term ‘fitness’ is used in a variety of ways. In order to describe fitness accurately, the fitness components should be referred to. The fitness components help us to understand the specific physical requirements required to successfully perform an activity.

**KEY KNOWLEDGE**

- Fitness components: definitions and factors affecting aerobic power, agility, anaerobic capacity, balance, body composition, coordination, flexibility, muscular endurance, power and strength, reaction time and speed

**KEY SKILL**

- Analyse data to determine the major fitness components and the factors that affect them, and the energy systems used in a variety of sporting events and physical activities

**CHAPTER PREVIEW**
8.1 Aerobic power and anaerobic capacity

**KEY CONCEPT** Aerobic power and anaerobic capacity are the building blocks for all other fitness components and are generally what people refer to when discussing general fitness.

**Aerobic power**

Aerobic power is the maximum rate of energy production from the aerobic energy system (i.e. energy produced in the presence of oxygen). The cardiovascular and respiratory systems work together to deliver oxygen to the working muscles for any physical exertion that requires aerobic power.

If the cardiovascular and respiratory systems are highly trained, the athlete will be better able to produce ATP for the working muscles under aerobic conditions (at a higher intensity for longer), and they will have increased capacity for efficiently replenishing the anaerobic systems during and/or after an extended performance in a sports event or physical activity.

Aerobic power is of high importance in:
- extended athletic events such as marathons, triathlons and cross-country skiing
- team sports requiring repeated efforts over a longer period of time
- racquet sports such as tennis and squash
- team games such as netball, football, hockey, soccer, volleyball, water polo, basketball, lacrosse and rugby.

**FIGURE 8.1** Aerobic power relies on the cardiovascular and respiratory systems working together.

**FIGURE 8.2** Long-distance cyclists require the highest levels of aerobic power in order to work at higher intensities for long periods of time, often for a number of days in a row.
Factors affecting power

**TABLE 8.1 Factors affecting aerobic power**

<table>
<thead>
<tr>
<th>Factor</th>
<th>Effect on aerobic power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>Aerobic power (VO$_2$ max.) peaks in the mid 20s and then decreases as age increases.</td>
</tr>
<tr>
<td></td>
<td>This is due to decreased elasticity of the lungs (decreased oxygen uptake), decreased</td>
</tr>
<tr>
<td></td>
<td>haemoglobin (decreased oxygen transport) and decreased muscle mass and therefore</td>
</tr>
<tr>
<td></td>
<td>mitochondria (decreased oxygen utilisation).</td>
</tr>
<tr>
<td>Sex</td>
<td>Males generally have a higher aerobic power (VO$_2$ max.) than females.</td>
</tr>
<tr>
<td></td>
<td>This is due to greater size of the lungs (increased oxygen uptake), increased</td>
</tr>
<tr>
<td></td>
<td>haemoglobin levels (increased oxygen transport) and increased muscle mass and</td>
</tr>
<tr>
<td></td>
<td>therefore mitochondria (increased oxygen utilisation).</td>
</tr>
<tr>
<td>Muscle fibre type</td>
<td>A greater percentage of slow-twitch fibres will increase aerobic power (VO$_2$ max.)</td>
</tr>
<tr>
<td></td>
<td>Slow-twitch fibres work aerobically, therefore the greater number of slow-twitch</td>
</tr>
<tr>
<td></td>
<td>fibres, the greater ability to work aerobically</td>
</tr>
</tbody>
</table>

**FIGURE 8.3** As age increases, aerobic power, measured by VO$_2$ max., decreases.

Some common ways to test aerobic power include:
- multi-stage fitness test
- yo-yo test
- Cooper 12-minute run test
- 2.4 km run test
- Rockport 1.6 km walking test
- VO$_2$ max. Astrand-Ryhming cycle ergometer test
- VO$_2$ max. treadmill test
- Harvard step-test. (See topic 9 for more details.)

The most appropriate training methods to develop aerobic power are continuous, fartlek, long-interval, HIIT and circuit training (see topic 11 for more details).
Aerobic power and anaerobic capacity

**Anaerobic capacity**

Anaerobic capacity is the total amount of energy obtainable from the anaerobic energy systems (the combined capacity of the ATP–CP system and anaerobic glycolysis system).

Anaerobic capacity is generally measured over a maximal effort up to one minute. As discussed in topic 5, during a maximal effort up to one minute the ATP–CP system will play a major role at the beginning and then the anaerobic glycolysis system will be predominant. The longer and more efficiently these systems can contribute significantly to performance, the greater an individual’s anaerobic capacity will be.

High anaerobic capacity can allow an athlete to complete longer maximal intensity efforts (for example, an elite 400 m sprint), but also repeat more maximal intensity efforts with limited recovery (for example, basketball rebounds).

**Factor affecting anaerobic capacity**

**TABLE 8.2** Factors affecting anaerobic capacity

<table>
<thead>
<tr>
<th>Factor</th>
<th>Effect on anaerobic capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>Anaerobic capacity peaks in the 20s and then decreases as age increases.</td>
</tr>
<tr>
<td>Sex</td>
<td>Males generally have a higher anaerobic capacity than females.</td>
</tr>
<tr>
<td>Muscle fibre type</td>
<td>A greater percentage of fast-twitch fibres will increase anaerobic capacity.</td>
</tr>
<tr>
<td>Lactate tolerance</td>
<td>The greater the lactate tolerance, the greater the anaerobic capacity.</td>
</tr>
</tbody>
</table>
FIGURE 8.5 The percentage of slow (red)- and fast (light pink)-twitch fibres is a significant factor affecting an individual’s anaerobic capacity.

The greater the percentage of fast-twitch fibres, the greater one’s ability to generate anaerobic energy and therefore the greater the anaerobic capacity. Sprinters and jumpers require high anaerobic capacity.

Some common ways to test anaerobic capacity are:
- Phosphate recovery test
- 30-second Wingate test
- Repco peak power test. (See topic 9 for more details.)

The most appropriate training methods to develop anaerobic capacity are short and intermediate interval training (see topic 11 for more details).

TEST your understanding
1. Define aerobic power.
2. List five sports or activities that you have played that require aerobic power.
3. Define anaerobic capacity.
4. List five sports or activities that you have played that require anaerobic capacity.
5. Outline the role of the three energy systems in producing aerobic power and anaerobic capacity.

APPLY your understanding
6. Explain the main differences between aerobic power and anaerobic capacity.
7. Discuss a time when aerobic power and anaerobic capacity are predominant during a triathlon.
8. Discuss when you would use aerobic power and when you would use anaerobic capacity during a team game such as basketball.
9 Practical activity: laboratory tests for aerobic power
As a class, thoroughly warm-up and stretch, then undertake the multi-stage fitness test (page xx, chapter 9) to predict each student’s aerobic power. Then select different students to also undertake the Harvard step-test (page xx, chapter 9).
(a) Explain the correlation between students’ aerobic power and their main sport.
(b) Outline the correlation between the different aerobic power tests.
(c) What variables may affect results? Explain how each test is specific to a sport when considering muscle groups/actions and energy system contribution.
(d) Explain the role of each energy system in achieving level 12 on the multi-stage fitness test.
(e) Explain how having good anaerobic capacity, as well as high aerobic power, may lead to success in these tests.
(f) Compare your results with those of two other students. Discuss what factors may have affected these results.

EXAM practice
10 Use figure 8.3 to answer the following questions.
(a) Identify the trends in the graph. 2 marks
(b) Explain a reason for each trend. 4 marks

11 Examine figure 8.5 and answer the following questions.
(a) Fast-twitch fibres are white and slow-twitch fibres are red. Using your understanding of the characteristics of fast- and slow-twitch fibres, discuss why this may be so. 2 marks
(b) Justify the predominance of fast-twitch fibres for weightlifters. 2 marks
8.2 Muscular strength, muscular power and muscular endurance

**KEY CONCEPT** Strength, power and muscular endurance all require a high force contraction for high-intensity efforts. While there are many similarities, including heavy reliance on the anaerobic energy pathways, it is important to understand the difference between these fitness components.

**Muscular strength**

*Strength* is the peak force that a muscle can develop. Apart from weight-lifting, this peak force strength movement is used infrequently in competitive or recreational sport. However, it is not difficult to imagine muscles creating near-peak force during sport participation.

Muscular strength is of high importance in:
- pushing with seven team mates against eight opponents in a Rugby Union scrum
- gripping a hockey stick while making a powerful shot at goal
- attempting a static or submission hold against an opponent in wrestling
- leaning out to try to keep a boat upright while sailing.

**FIGURE 8.6** Pushing against your team mates and against the opposition is an example of muscular strength.

**Factors affecting strength**

**TABLE 8.3** Factors affecting muscular strength in the individual

<table>
<thead>
<tr>
<th>Factor</th>
<th>Effect on strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed of muscle</td>
<td>The more slowly a muscle contracts, the more force it can create (figure 8.7). Compare an isometric contraction with a powerful, isotonic contraction. A 1 RM weight lift is performed much more slowly than 12 RM movements, because it requires more strength.</td>
</tr>
<tr>
<td>contraction</td>
<td></td>
</tr>
<tr>
<td>Length of muscle</td>
<td>If the muscle is slightly stretched, it is in the best position to create its maximum force. This is demonstrated when long jumpers lower their centre of gravity just before take-off — a movement that stretches the quadriceps just before they contract to achieve the powerful leap. Performers need to account for this fact along with the best ‘joint angle’ specific to the particular joint around which the movement is centred.</td>
</tr>
<tr>
<td>fibre</td>
<td></td>
</tr>
</tbody>
</table>

(continued)
Muscular strength, muscular power and muscular endurance

### TABLE 8.3 (continued)

<table>
<thead>
<tr>
<th>Factor</th>
<th>Effect on strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age of the performer</td>
<td>Strength peaks in performers aged 20–30 years, then decreases with the body’s diminishing ability to process protein. Regular exercise can slow this process.</td>
</tr>
<tr>
<td>Warm-up</td>
<td>Warmed-up muscles have a greater ability to create strength than muscles that are not warmed up.</td>
</tr>
<tr>
<td>Fibre type</td>
<td>Fast-twitch (or white) fibres are capable of greater strength output than that of slow-twitch (or red) fibres.</td>
</tr>
<tr>
<td>Cross-sectional area</td>
<td>The larger the muscle, the greater the strength potential (figure 8.8). But this relates to the muscle mass, not the total body area in which the muscle is found. The diameter of the biceps, for example, may include both muscle and fat.</td>
</tr>
<tr>
<td>Sex of the performer</td>
<td>Males generally have greater muscle mass, so they have greater absolute strength. Relative to the cross-sectional area of muscle, there is no difference in the strength available to males and females (see figure 8.8).</td>
</tr>
<tr>
<td>Joint angle around the muscle</td>
<td>For each joint angle in movement there is an optimal angle for the creation of strength (figure 8.9).</td>
</tr>
</tbody>
</table>

- **FIGURE 8.7** As speed of contraction increases, the amount of force created decreases.

- **FIGURE 8.8** As the cross-sectional area of muscle increases, the strength potential also rises.

- **FIGURE 8.9** The strength available as a joint moves depends on the angle of the joint.

Some common ways to test muscular strength include:
- the **1 RM** (bench press, back squat, leg press)
- grip strength dynamometer
- push-pull dynamometer
- Seven-stage abdominal strength test (see topic 9 for more details).

The most appropriate training method to develop muscular strength is resistance training (see topic 11 for more details).

**Muscular power**

Muscular power is the ability of a muscle or group of muscles to exert a maximum amount of force in the shortest period of time.

1 RM (1 repetition maximum) is the maximum amount of force that can be generated in one maximal contraction. This is commonly used to measure strength.

Muscular power is the ability of a muscle or group of muscles to exert a maximum amount of force in the shortest period of time.
Muscular power is important in:
- field events such as shot put, discus, javelin, high jump, long jump and hammer throw
- Rugby League or Rugby Union tackles
- volleyball spikes
- netball or basketball when the player leaps to intercept the ball
- hockey when the player performs a defensive clearance
- golf when the golfer drives the ball
- the legs in a sprint
- the arms in a tennis serve
- the legs and arms in a gymnastics floor routine.

Factors affecting muscular power
The factors affecting power are the same as those affecting muscular strength, as power combines strength and speed (see fig 8.3).

Some common ways to test power are:
- vertical jump
- standing long jump
- Magaria Kalamen power test
- the basketball throw. (See topic 9 for more details.)

The most appropriate training method to develop muscular power is plyometrics training. Resistance training with fast contractions and appropriate recovery between repetitions is also commonly used to develop power (see topic 11 for more details).
Muscular endurance

Muscular endurance is the ability of a muscle or group of muscles to sustain repeated contractions against a resistance for an extended period of time.

Muscular endurance is often controlled by the body’s tolerance of the increasing levels of lactate, which is a by-product of the glycolytic energy pathways. Heavy arms or legs during any high-intensity effort of around 60 seconds are a direct result of the body’s ability to tolerate building levels of lactate and are an indicator of the person’s muscular endurance. Muscular endurance is also important in endurance events, which may be aerobic in nature but require repeated efforts from a muscle or muscle group.

Muscular endurance is of high importance for:
- the arms, legs and abdominals in a 200-metre swim
- the abdominals, hip muscles and legs in a marathon
- the arms, legs and abdominals in a 2000-metre rowing race
- the arms, legs and abdominals in most team games.
Factors affecting endurance

TABLE 8.4 Factors affecting muscular endurance

<table>
<thead>
<tr>
<th>Factor</th>
<th>Effect on muscular endurance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>Males generally have greater muscular endurance than females. Males have increased aerobic capacity and muscular strength, therefore increased endurance compared to females.</td>
</tr>
<tr>
<td>Muscle fibre type</td>
<td>A greater percentage of slow-twitch fibres will increase muscular endurance. Slow-twitch fibres work aerobically, therefore the greater the number of slow-twitch fibres, the greater the ability to work aerobically and contract repeatedly over a longer period of time. Slow-twitch fibres have greater resistance to fatigue than fast-twitch.</td>
</tr>
<tr>
<td>Lactate tolerance</td>
<td>The greater the lactate tolerance, the greater the anaerobic capacity. The more metabolic by-products that can be tolerated, the more high-intensity efforts/longer high-intensity efforts can be made.</td>
</tr>
</tbody>
</table>

Some common ways to test muscular endurance are:
- 60-second push-up test
- 30-second sit-up test
- Curl-up (crunch) test
- Pull-up/modified pull-up test
- Flexed arm hang test. (See topic 9 for more details.)

The most appropriate training methods to develop muscular endurance where the anaerobic energy system is predominant are resistance (with high repetitions and little recovery) and intermediate interval training.

For muscular endurance where the aerobic system is predominant, the most appropriate training methods would be the same as those used to develop aerobic power (see topic 11 for more details).

TEST your understanding
1. Define the term muscular strength.
2. Define the term muscular power.
3. Define the term muscular endurance.
4. Apart from those listed in muscular power, list five sporting actions that exemplify muscular power.

APPLY your understanding
5. Outline the differences between muscular strength, muscular endurance and muscular power. Use sporting examples in your response.
6. Identify and justify the following movements as muscular strength, power or endurance:
   - 1 RM leg press
   - 1 minute of step-ups
   - Maximal bench jump.
7. Practical activity: muscle endurance test
   As a class, thoroughly warm-up and stretch, then undertake one of the following muscle endurance tests, recording the results:
   - Number of push-ups in 60 seconds
   - Number of bench jumps in 60 seconds
   - Number of sit-ups in 60 seconds.
   (a) Present the collected data in tables and graphs.
   (b) Examine the varying results and explain possible reasons for at least two differences in results.
Practical activity: Fly game

Use the Fly game weblink in your eBookPLUS to learn how to play the game of Fly.

(a) Collect six stick-like objects.
(b) Spread sticks out 1 m apart.
(c) Line up.
(d) Each person takes a turn to run through the sticks placing one foot between each stick, making sure they do not touch the stick with their feet.
(e) The last person in line takes an extra leap from last step.
(f) Move the last stick to the back of the last jumper’s foot so the gap between the fifth and sixth sticks is now bigger.
(g) Repeat the process from this end. The first step should now be bigger.
(h) Last jumper jumps and last stick is moved.
(i) Keep going until there is only one person left who can jump between the increasing gaps in one step and not touch the sticks.

A modification is that you allow the last jumper to move any stick.

After you have completed the learning activity, explain how increased muscular power increases the chance of success in the game of Fly.

EXAM practice

9

(ACHPER trial Exam 2014, question 5 a and b)

(a) Describe the trend shown by the graph. 1 mark
(b) Explain how an increase in cross-sectional size of muscle produces increased muscular strength. 2 marks
8.3 Speed and agility

KEY CONCEPT Speed is very important in many sports but it is arguably more important, especially in team sports, to have the ability to change direction at speed: agility.

Speed

Speed is the rate of motion (distance/time). For sporting performance, speed is defined as the ability to move the body or part of the body from one point to another as quickly as possible.

FIGURE 8.14 Sprint cycling requires full-body speed.

FIGURE 8.15 Table tennis players require part-body speed to react and return the ball.
Speed is important in:
- undertaking any sprint event in athletics
- accelerating to create space or evade an opponent in team games
- releasing a javelin or discus
- racquet and club speed in striking sports.

**Factors affecting speed**

<table>
<thead>
<tr>
<th>Factor</th>
<th>Effect on speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Muscle fibre type</td>
<td><em>A greater percentage of fast-twitch fibres will increase speed.</em> Fast-twitch fibres generate increased force production and power output, therefore increase speed.</td>
</tr>
<tr>
<td>Reaction time</td>
<td><em>The faster the reaction time, the greater the speed.</em></td>
</tr>
<tr>
<td>Sex</td>
<td><em>Males generally have greater speed than females.</em></td>
</tr>
<tr>
<td></td>
<td>Males have increased levels of testosterone therefore increased muscle mass, providing the capacity to generate more force and therefore increased speed.</td>
</tr>
<tr>
<td>Age</td>
<td><em>As age increases, speed decreases (negative linear relationship).</em></td>
</tr>
<tr>
<td></td>
<td>This is due to decreased ability to use protein (protein synthesis) and decreased muscle mass, therefore decreased speed.</td>
</tr>
<tr>
<td>Flexibility</td>
<td><em>The greater the flexibility/stride/stroke length, the greater the speed.</em></td>
</tr>
<tr>
<td></td>
<td>Increased range of motion, due to increased flexibility, means an athlete can get further in each stroke/stride, making them more efficient in technique and increasing speed.</td>
</tr>
</tbody>
</table>

**FIGURE 8.16** Usain Bolt is significantly taller than many of his opponents and has a greater stride length.

Some common ways to test speed include:
- 20-metre sprint test
- 35-metre sprint test
- 50-metre sprint test. (See topic 9 for more details.)

The most appropriate way to develop speed is by using short-interval training (see topic 11 for more details).
Agility

Agility combines speed with flexibility and dynamic balance, allowing the performer to change direction with maximal speed and control.

In sports such as gymnastics, planned agility is required. Most sports, such as team sports, require reactive agility where players are required to change direction in response to a stimulus.

Agility is of high importance in:
- evading an opponent in soccer or rugby
- reacting to an opponent's baulk in hockey
- dribbling the ball around opponents in soccer or basketball
- changing direction during a dance, gymnastics or aerobics sequence
- moving to make a play in squash while avoiding an opponent.

![FIGURE 8.17 Agility is of high importance when dribbling around opponents in basketball. Many sports such as the NBL and AFL have developed specific agility tests to replicate the requirements of the game. Basketballers require agility to move around and past opponents and team mates.](image1)

![FIGURE 8.18 In order to change direction and go up and over the bar, a pole vaulter requires high levels of agility as Henry Brown, Australia, demonstrates.](image2)
The factors affecting agility are similar to those affecting speed as agility requires speed (see table 8.5).
Some common ways to test agility are:
- the Semo agility test
- 5-0-5 agility test
- the Illinois agility test. (See topic 9 for more details.)

The most appropriate training method to develop agility is short-interval training, ideally with changes of direction; for example; shuttle run sprints. (See topic 11 for more details.)

**TEST your understanding**

1. Define the term speed.
2. Explain the difference between full-body speed and part-body speed.
3. Apart from those given in this section, list five sports or sporting actions where whole body speed is required, and five where part-body speed is required.
4. Define the term agility.
5. Identify the three fitness components that comprise agility.

**APPLY your understanding**

6. **Learning activity: self-designed agility test**
   Select a team sport and design an agility test that mimics the movement patterns required in the game.
   For example:
   - Netball: a centre player’s first five seconds of movement following a centre pass
   - Australian Rules Football: an on-baller’s first five seconds of movement following a centre bounce
   - Hockey: the inside-right’s movement as the team makes an attacking break from defence.

7. **Class activity: the need for speed**
   Rank the following actions or activities in order of importance with respect to speed. Rank them from 1 (very important) to 11 (not very important).
   - Multi-stage fitness test (or beep test)
   - 50-metre running sprint test
   - Javelin throw
   - Marathon
   - Tennis serve
   - Shane Warne’s spin bowling
   - Basketball free-throw
   - Skipping with a skipping rope
   - Netball centre pass
   - Lead from a full forward in AFL
   - Water polo 5-metre penalty throw

8. **Practical activity: team sport**
   As a class, participate in any team sports game. Discuss whether speed or agility would be more desirable in the team game played and justify your response.

**EXAM practice**

9. Speed and agility are vital in a successful gymnastics floor routine. Explain the role each of these fitness components would play, using specific examples. 4 marks
8.4 Flexibility and balance

**KEY CONCEPT** Flexibility and balance are important when considering injury prevention. However, they have a significant impact on skill execution and, ultimately, successful skill and sports performance.

**Flexibility**

Flexibility is the range of movement around a joint. It is the interaction between the body's skeletal and muscular systems to allow a full and unimpeded range of joint movement to muscle actions.

Flexibility is of high importance when:
- performing gymnastics routines on the Roman rings, uneven bars, parallel bars, floor, pommel horse and beam
- goalkeeping in hockey
- performing competitive aerobics
- catching in short-stop or catcher positions in softball or baseball.

Flexibility is essential to all sports and recreational activities, therefore it must be an integral part of all fitness training programs. It is specific to the sport or activity, because some sports require more flexibility of more body parts than do others. Flexibility may be dynamic (moving) or static (stationary). Generally, it needs to be dynamic, and it is often combined with speed to create agility.

**Factors affecting flexibility**

<table>
<thead>
<tr>
<th>Factor</th>
<th>Effect on flexibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific sport and joint flexibility</td>
<td>Flexibility importance differs from one sport to the next — for example, gymnastics requires much more all-round flexibility than does rowing.</td>
</tr>
<tr>
<td>Somatotype</td>
<td>Endomorphs with their extra bulk (from extra adipose tissue) have limited flexibility. Mesomorphs also may have limited flexibility because they have trained with a limited range of movement or because they have extra muscle tissue. Ectomorphs generally have quite good flexibility because they have lower amounts of body tissue.</td>
</tr>
<tr>
<td>Skin resistance</td>
<td>Skin has lower elasticity than that of ligaments and tendons, so it can restrict higher ranges of movement.</td>
</tr>
<tr>
<td>Sex</td>
<td>Hormonal differences mean that females are generally more flexible than males.</td>
</tr>
</tbody>
</table>

**FIGURE 8.19** Olympic champion Simone Biles of the United States demonstrates (a) dynamic flexibility and (b) static flexibility on the balance beam in the women's all-around gymnastics at the Rio 2016 Olympic Games.
8.4 Flexibility and balance

### TABLE 8.6 (continued)

<table>
<thead>
<tr>
<th>Factor</th>
<th>Effect on flexibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of joint</td>
<td>Specific joints are designed for either strength or mobility, or a combination of each. The shoulder has great mobility but is prone to dislocation in contact sports. The hip joint has high stability, but less mobility than that of the shoulder.</td>
</tr>
<tr>
<td>Resting length of ligaments and joint capsule</td>
<td>Stretching these surrounding structures in training may increase a joint's flexibility.</td>
</tr>
<tr>
<td>Age</td>
<td>Increasing age decreases flexibility.</td>
</tr>
<tr>
<td>Warm-up</td>
<td>Warm-up routines generally increase the temperature of both the muscles and the structures within the joints, increasing flexibility.</td>
</tr>
<tr>
<td>Length of muscles at rest</td>
<td>If muscles at rest are shortened, then flexibility is limited. This may happen if the individual has too much sedentary work (which chronically shortens the hamstrings). If weight-training exercises are not performed through the full range of motion, then the muscles will shorten.</td>
</tr>
<tr>
<td>Bone</td>
<td>Depending on the joint, the bone type and structure will vary and thus have different effects on the actual flexibility of the joint.</td>
</tr>
</tbody>
</table>

Some common ways to test for flexibility include:
- Trunk flexion (sit-and-reach) test
- Trunk rotation test
- Groin flexibility test
- Shoulder and wrist elevation test
- Trunk and neck extension test
- Ankle extension/dorsiflexion test
- Shoulder rotation test. (See topic 9 for more details.)

The most appropriate training method to develop flexibility is specialised flexibility training (stretching). (See topic 11 for more details.)

### Balance

**Balance** is the ability of the body to remain in a state of equilibrium while performing a desired task.

There are two recognised types:
1. dynamic balance, which involves keeping the body’s balance under control while moving
2. static balance, which involves keeping the body’s balance under control while not moving.

![FIGURE 8.20 Sailing and aerobics often require high levels of balance.](image)
Balance is a fitness component that is central to all physical activity and is often the discriminating factor between excellent and average performance. For example, consider a 200-metre sprint in athletics, especially as the runners come around the bend. The sprinters run at varying distances from the inside line of their lanes, and their accompanying control of style, balance and speed ultimately contributes to their success at the finish.

Balance is of high importance when:
- running around a bend in a 200-metre athletic race
- performing a 60-second aerobics routine
- performing a handstand in a gymnastics routine
- standing on one foot while shooting a goal in netball.

**Factors affecting balance**

Factors that affect balance include the mass of the object, the centre of gravity, the base of support and the line of gravity (as discussed in chapter 2).

Other issues that can affect one's balance include:
- any issues with the ears
- decreased muscle mass, often associated with ageing.

The stork stand test is a common way to test balance but many sports will have sports-specific balance tests.

Balance can be developed using resistance training of the core muscles (see topic 11 for more details).

**TEST your understanding**

1. Define the term flexibility.
2. Name the two body systems that work together to achieve flexibility.
3. Apart from those given in this section, list five sports or sporting actions that exemplify flexibility.
4. Define the terms static balance and dynamic balance.

**APPLY your understanding**

5. Select three different sporting or outdoor activities. Make a list of the skills needed for each activity and assess whether they require static or dynamic balance, or a combination of the two.
6. Outline why flexibility is essential to every sports training session.
7. Study the factors that affect flexibility (table 8.6). Select your favourite sport and examine how each of the factors influences the level of achievement of an elite performer in this sport.
8. Using examples of dynamic and static flexibility in sporting situations, illustrate the differences between the two types of flexibility.
9. In groups of three or four, arrange to visit a training session of one of your school's sports teams.
   - (a) List the flexibility work done by the team during the session.
   - (b) Discuss the purpose of the flexibility work completed.

10. **Practical activity: group fitness**
    - Complete a group fitness class such as pilates, Body Balance or yoga.
      - (a) Justify how classes like this can help improve flexibility and balance.
      - (b) Many AFL footballers include at least one session a week of pilates, Body Balance or yoga. Explain how this may improve performance in AFL.

**EXAM practice**

11. Explain how sex and age affect flexibility.  
    2 marks
8.5 Body composition, coordination and reaction time

**KEY CONCEPT** Body composition, coordination and reaction time are considered fitness components, as they can impact performance. While they can be harder to test and train for specifically, they can still have a significant influence on performance.

**Body composition**

Body composition refers to the relative proportions of bone, muscle and fat within the body. Lean tissue is composed of muscle, bone and organs. Fat tissue is composed of essential and storage fats (both necessary for the body to function), and non-essential fat.

Interest in body composition mostly centres on how to measure lean body mass compared with body fat content. The accepted ranges of body fat considered safe for good health are:
- 5–18 per cent for males
- 12–25 per cent for females.

There is little evidence of any sporting performance or health benefits when males drop under 8 per cent body fat and women drop under 14 per cent body fat.

**Factors affecting body composition**

<table>
<thead>
<tr>
<th>Factor</th>
<th>Effect on body composition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>As age increases (until mid 50s–60s), there is an increased likelihood of higher body fat content and decreased muscle mass.</td>
</tr>
<tr>
<td>Sex</td>
<td>Males are more likely to be obese than females but females are less likely to have high levels of muscle mass.</td>
</tr>
<tr>
<td>Genetics</td>
<td>Likely to be similar body composition to parents.</td>
</tr>
<tr>
<td>Diet and physical activity levels</td>
<td>Positive energy balance, where energy input is greater than energy output, will result in increased body fat.</td>
</tr>
</tbody>
</table>

**FIGURE 8.21** As age increases from 18 years old, the percentage of obese persons increases until approximately 55 years of age. Data shown from 2011–12.
Body composition can be tested by:
- body mass index
- waist circumference
- skinfold measurements
- hydrodensitometry (underwater) weighing
- bioelectrical impedance and DEXA and TOBEC scans.

Underwater weighing is a sophisticated process that requires specialist, expensive equipment and complex calculations. However, it is considered ‘the gold standard’ (the most accurate) for body composition assessment. The process of hydrodensitometry requires the participant to be completely submerged within the weighing tank and to exhale all air possible while underwater. This type of assessment is for those with an invested interest in their body composition (see topic 9 for more details).

In order to improve body composition, a variety of training methods can be used. Generally, aerobic training will help decrease fat and anaerobic training can help build muscle.

**Coordination**

Coordination is the ability to use different parts of the body together smoothly and efficiently.

It comes from the interaction of the neural, muscular and skeletal body systems. Coordination is a complex fitness component that requires sound levels of other fitness components such as strength, balance and agility. In sport, someone who appears well coordinated may also be described as having good timing.

Some sports require hand-eye coordination, some require foot-eye coordination and many require a combination of both.

**FIGURE 8.22** Hockey requires excellent hand-eye coordination whereas soccer mainly relies on foot-eye coordination.

Coordination is of high importance when:
- performing dance, aerobics and ballet movements
- casting the shot in shotput
- hitting a cover drive for four runs in cricket
- scoring from a netball shot
- spiking in volleyball
- performing all routines in gymnastics.

If you have poor vision and hearing, it can affect your coordination. Experience and stage of development can also slightly affect coordination.
Reaction time

Reaction time is the time between a stimulus and the first response. The average reaction time is 0.2 seconds. Reaction time is the ability of the brain to react to various outside input sources, process them, select a response, then activate the expected muscular response.

A performer with better reaction time is usually the dominant player who appears controlled and rarely flustered and is usually able to impart maximum force to a desired movement. Faster reaction times allow the performer to be well positioned at the critical moments. Performers can improve their reaction time with specific training.

Reaction time is of high importance when:
- catching in the slips in cricket
- reacting to the starter’s gun in a sprint race
- deciding which player is in the best position to receive a pass in basketball
- judging the probable direction of the ball from an opponent’s back swing in tennis.

Reaction time can be tested using the ruler drop test or sport-specific tests. Reaction time is generally improved through sport-specific training.

Factors affecting reaction time

<table>
<thead>
<tr>
<th>Factor</th>
<th>Effect on reaction time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>Reaction time increases with age (gets slower). Fastest between the ages of 19 and 30</td>
</tr>
<tr>
<td>Sex</td>
<td>Men will generally have a faster reaction time than women.</td>
</tr>
<tr>
<td>Intensity of the cue</td>
<td>Greater intensity = shorter reaction time as it is more easily detected. Easier to detect therefore quicker to react to.</td>
</tr>
<tr>
<td>Factor</td>
<td>Effect on reaction time</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>-----------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Number of choices</td>
<td>Simple Reaction Time — only one cue and one response (therefore, the choice is simple)</td>
</tr>
<tr>
<td></td>
<td>Choice Reaction Time — more than one cue and one or more possible responses</td>
</tr>
<tr>
<td></td>
<td>The greater the number of choices a performer has, the greater the reaction time will be.</td>
</tr>
<tr>
<td>Probability of the cue occurring</td>
<td>Anticipation/experience of cue occurring will reduce reaction time.</td>
</tr>
<tr>
<td>Presence or absence of warning signs</td>
<td>Presence of warning signs will reduce reaction time. E.g. “On your marks, set, go!”</td>
</tr>
</tbody>
</table>
KEY SKILLS  FITNESS COMPONENTS

KEY SKILL

- Analyse data to determine the major fitness components and the factors that affect them, and the energy systems used in a variety of sporting events and physical activities.

UNDERSTANDING THE KEY SKILL

To address this key skill, it is important to remember the following:

- Name and describe fitness components
- Identify and justify the importance of fitness components based on data
- Describe factors that affect each fitness component

PRACTICE QUESTION

a. Identify an important fitness component required to compete the action above. (1 mark)

b. Discuss a factor that affects the above fitness component. (2 marks)

SAMPLE RESPONSE

a. Flexibility

b. Joint type. The shoulder is a ball-and-socket joint allowing for increased range of movement, full golf swing, and therefore greater flexibility.
CHAPTER REVIEW  FITNESS COMPONENTS

CHAPTER SUMMARY

- Fitness components are those aspects of fitness that should be performed to a reasonable level in any sport or activity.
- By addressing fitness components, as opposed to ‘fitness’, assessment can be more specific.
- Aerobic-based fitness components include aerobic power, muscular endurance and flexibility.
- Anaerobic-based fitness components include agility, anaerobic capacity, muscular power, muscular strength and speed.
- Balance, reaction time and coordination are fitness components that are determined by the interaction between an individual’s mental processes and muscular movements.
- Body composition can impact a person’s performance in an activity. Different body compositions tend to lend themselves to different sports.
- Age, sex and the percentage of fast or slow muscle fibres significantly affect most fitness components.

EXAM PREPARATION

MULTIPLE CHOICE QUESTIONS

1. The ability to utilise oxygen to generate energy is called
   (A) anaerobic capacity.
   (B) muscular endurance.
   (C) aerobic capacity.
   (D) aerobic power.

2. Which of the following events is most likely to rely predominately on muscular power?
   (A) 100 m sprint
   (B) Shot put
   (C) Weightlifting
   (D) 400 m sprint

3. Which of the following best describes the relationship between muscle fibre type and anaerobic capacity?
   (A) A 50/50 percentage of slow- and fast-twitch fibres will result in the greatest anaerobic capacity
   (B) The greater the percentage of slow-twitch fibres, the greater the anaerobic capacity
   (C) The greater the percentage of fast-twitch fibres, the lower the anaerobic capacity
   (D) The greater the percentage of fast-twitch fibres, the greater the anaerobic capacity

4. A one-off maximal effort against resistance requires which fitness component?
   (A) Muscular power
   (B) Speed
   (C) Muscular strength
   (D) Balance

5. Agility does not rely on which other fitness component/s?
   (A) Speed
   (B) Balance
   (C) Coordination
   (D) Flexibility

6. Who is likely to generate the greatest speed?
   (A) An individual with 85% fast-twitch muscle fibres
   (B) An individual with 85% slow-twitch muscle fibres
   (C) A 50-year-old male
   (D) A 50-year-old female

7. Dynamic flexibility is
   (A) flexibility around all joints.
   (B) flexibility when moving.
   (C) flexibility when stationary.
   (D) flexibility done at the end of a training session.

8. Which of the following best describes an endomorph?
   (A) More body fat than muscle
   (B) More muscle than body fat
   (C) Little fat and muscle
   (D) Lots of fat and muscle
CHAPTER REVIEW  FITNESS COMPONENTS

9 Reaction time is closely linked to which body system?
   (A) Cardiovascular system
   (B) Central nervous system
   (C) Respiratory system
   (D) Muscular system

10 Females tend to have a physiological advantage over males of similar age in which fitness component?
   (A) Flexibility
   (B) Aerobic power
   (C) Muscular power
   (D) Anaerobic capacity

TRIAL EXAM QUESTIONS

Question 1  (ACHPER Trial Exam 2013, question 9 b and c)

Claire and Rachel are Year 12 Physical Education students. Claire likes to swim and wants to design a training program that will improve her 400 m freestyle time. Her best time is 5 minutes 20 seconds but Claire would like to improve by 10 seconds and swim 5 minutes 10 seconds. Rachel competes with a local athletics club and wants to improve her 1500 m run time. Her best time is 5 minutes and she believes that with a well-designed training program she can improve her time to 4 minutes and 50 seconds.

Both girls undertook four fitness tests as part of their pre- and post-testing battery.

<table>
<thead>
<tr>
<th>Fitness component</th>
<th>Claire</th>
<th>Rachel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerobic capacity</td>
<td>20 metre shuttle run test</td>
<td>20 metre shuttle run test</td>
</tr>
<tr>
<td>Flexibility</td>
<td>Shoulder and wrist elevation test</td>
<td>Sit-and-reach test</td>
</tr>
<tr>
<td>Muscular endurance</td>
<td>Timed sit-up test</td>
<td>Timed sit-up test</td>
</tr>
<tr>
<td>Muscular strength</td>
<td>1 RM bench press test</td>
<td>1 RM leg press test</td>
</tr>
</tbody>
</table>

a. Suggest an appropriate aerobic capacity test that Claire would have chosen.
   1 mark

Question 2

a. Complete the table below showing an understanding of muscular strength, power and endurance.
   5 marks

<table>
<thead>
<tr>
<th>Component of fitness</th>
<th>Description</th>
<th>Example of a recognised fitness test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Muscular power</td>
<td>Vertical jump</td>
<td>1 RM bench press</td>
</tr>
<tr>
<td></td>
<td>Ability of a muscle or muscle group to perform repeated muscular contractions</td>
<td></td>
</tr>
</tbody>
</table>

b. List two factors and explain how each factor affects the strength of a muscle.
   4 marks