Overview

Training for improved performance
- Training for strength
- Training for power and speed
- Training for endurance
- Training for flexibility
- Training for skill and improvement

How competition affects performance
- Phases of competition
- Dietary considerations
- Environmental considerations
- Psychological preparation

Coaching considerations
- Establishing training programs
- Elements of a training session
- Overtraining
- The use of technology

Outcomes

On completion of this chapter, you will be able to:
- explain the relationship between physiology and movement potential (H7)
- explain how a variety of training approaches and other interventions enhance performance and safety in physical activity (H8)
- explain how movement skill is acquired and appraised (H9)
- design and implement training plans to improve performance (H10)
- design psychological strategies and nutritional plans in response to individual performance needs (H11)
- devise methods of gathering, interpreting and communicating information about health and physical activity concepts (H16)
- select appropriate options and formulate strategies based on critical analysis of the factors that affect performance and safe participation (H17)
- value the technical and aesthetic qualities of, and participation in, physical activity. (V&A)
Training is the fundamental ingredient that sustains physical performance, because it improves energy production, skill execution and stress tolerance. Effective training programs target the needs of each individual in terms of work volume and intensity. The program should seek overall improvement in skill, flexibility, strength, speed, endurance and power. It should also address the athlete’s nutritional needs and develop his or her psychological capacities.

**Training for strength**

One of the most important elements of any training program is its ability to develop force or speed or to shorten the period of time over which a muscle contracts. These features can be acquired through strength training programs, which vary considerably, depending on exactly which components are in most demand. Strength training is an essential part of any sport preparation program.

Strength training should not be thought of as competitive weight-lifting, as seen in Olympic sports or event power lifting. It must be an individualised program with a specific aim, such as:

- improving muscular endurance
- increasing strength
- developing power
- increasing body bulk
- enhancing muscle tone.

However, a strength training program will not be effective, nor will appropriate strength gains be made, unless the training program:

- is exercise specific; that is, adaptations will occur only in the parts of the body that are stressed by the exercise. Weight training is highly specific. For example, biceps development will generally have little effect on an athlete’s running ability.
- employs the overload principle; that is, the individual is loaded beyond normal requirements
- uses progressive resistance; that is, resistance is increased as adaptations occur.

There are four types of strength: absolute strength, relative strength, strength endurance and power.

- **Absolute strength** is the maximum force that can be generated by a muscle; for example, hand and wrist muscles in squeezing a grip dynamometer or the biceps brachii in lifting the maximum weight possible during an arm curl.
- **Relative strength** is the maximum strength that can be generated by a muscle relative to a person’s weight. For example, if a 70-kilogram person and an 80-kilogram person are each able to bench press 100 kilograms maximum, the 70-kilogram person has the higher relative strength.
- **Strength endurance** or **muscular endurance** is the ability of a muscle group to withstand fatigue. For example, someone who can row for 10 minutes has greater strength endurance than someone who can row for only five minutes.
- **Speed strength** or **power** is the ability to apply force at a rapid rate. Commonly known as elastic strength, it is required in explosive sports involving movement, for example jumping and sprinting.
Exercise design for major muscle groups

Like many sports, strength training has its own terminology. The most common terms used include:

- **repetitions** — the number of times an exercise is repeated without rest
- **repetitions maximum** — the maximum weight that can be lifted a specified number of times. For example, 1 RM equals the maximum weight that can be lifted only once; 8 RM equals the maximum weight that can be lifted eight times.
- **set** — a number of repetitions done in succession, for example one set equals 10 repetitions
- **resistance** — the weight or load
- **rest** — the period of time between exercises, sets or sessions
- **periodisation** — the process of varying the training load over discrete periods of time.

All strength programs utilise repetition of a series of exercises and overload to work a muscle group. This is effective because a muscle that is worked close to its capacity to generate peak force will experience gains in strength. If the tension is lower than two-thirds of the muscle’s maximal force, the muscle will not experience strength gains. Hence the importance of the overload principle, which equates to increasing tension in the case of strength. As the muscle adapts to a particular load, the resistance must be increased, otherwise significant gains will not be made.

By varying the resistance (weight), speed, repetitions, sets and rest, the required muscle fibres for the activity (either fast twitch or slow twitch) are recruited and developed. Safe performance of resistance training movements requires:

- a level that is appropriate to each individual, with competition being discouraged
- adequate warm-up and cool-down phases, including considerable emphasis on stretching
- focus on major muscle groups
- concentration on form and technique and not on increasing resistance too quickly
- the use of record cards to monitor progress
- equipment that is adequately maintained.

Special techniques include:

- breathing in as the weight is lifted and out as it is lowered
- never holding one’s breath as this increases blood pressure
- lifting with rhythm as opposed to jerky movements.

Any weight-training session should start with exercises involving large muscle groups early in the workout and specific exercises towards the end of the workout. Table 14.1 illustrates sample exercises that develop large muscle groups, but there are literally hundreds. It should be noted, however, that improvements are dictated by intensity, not by the type of exercise.
Table 14.1: Some exercises commonly used in resistance training programs

<table>
<thead>
<tr>
<th>Exercise</th>
<th>Muscle group</th>
<th>Description</th>
<th>Illustration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Squats</td>
<td>Legs</td>
<td>Use an overgrip (knuckles up). Keep head up and back flat. Squat until the thighs are parallel to the floor.</td>
<td><img src="squats.png" alt="Squats Illustration" /></td>
</tr>
<tr>
<td>Leg press</td>
<td>Legs</td>
<td>Lie under the press-bar with feet extended to make contact with a fastened bar or platform. Extend knees, hold and return.</td>
<td><img src="leg-press.png" alt="Leg Press Illustration" /></td>
</tr>
<tr>
<td>Leg curl</td>
<td>Hamstrings</td>
<td>With body lying face down on the bench, lock heels over rollers. Grasp front of bench and bring heels over until rollers touch back of thigh.</td>
<td><img src="leg-curl.png" alt="Leg Curl Illustration" /></td>
</tr>
<tr>
<td>Bench press</td>
<td>Chest, arms and shoulders</td>
<td>Lying face up on bench, hold bar with overgrip (palms forward) and with hands slightly wider than shoulders. Push bar up and then lower until it touches the chest.</td>
<td><img src="bench-press.png" alt="Bench Press Illustration" /></td>
</tr>
<tr>
<td>Upright rowing</td>
<td>Upper arms and shoulders</td>
<td>Using an overgrip (knuckles on top) hold bar in front of body with hands five centimetres apart. Lift the bar to the chin, keeping the elbows higher than the bar and then return.</td>
<td><img src="upright-rowing.png" alt="Upright Rowing Illustration" /></td>
</tr>
<tr>
<td>Lats pull-down</td>
<td>Back</td>
<td>Space hands widely apart on the bar. While kneeling, pull the bar until it touches the back of the neck.</td>
<td><img src="lats-pull-down.png" alt="Lats Pull-Down Illustration" /></td>
</tr>
<tr>
<td>Exercise</td>
<td>Muscle group</td>
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<td>Illustration</td>
</tr>
<tr>
<td>----------------</td>
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<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>--------------</td>
</tr>
<tr>
<td>Heel raise</td>
<td>Calf muscles</td>
<td>With bar across shoulders and back straight, place balls of feet on a board. Keeping the body erect, rise on toes as high as possible and lower until heels touch the floor.</td>
<td><img src="image1" alt="Heel raise" /></td>
</tr>
<tr>
<td>Crunches</td>
<td>Abdominals</td>
<td>Hold a weight on the chest. Lie with the hips flexed. Sit up with curling action, taking shoulders as far off the ground as possible, then return to the floor.</td>
<td><img src="image2" alt="Crunches" /></td>
</tr>
<tr>
<td>Back extensions</td>
<td>Lower back</td>
<td>Lie across a bench with heels hooked under a roller. Place hands behind head and bend forward until trunk is at right angles to the legs. Raise body to straight position.</td>
<td><img src="image3" alt="Back extensions" /></td>
</tr>
<tr>
<td>Lateral raises</td>
<td>Deltoids</td>
<td>From a prone position on a bench, grasp dumbbells. Raise sideways to a horizontal position. Return to start. Do not lock elbow joint during the movement.</td>
<td><img src="image4" alt="Lateral raises" /></td>
</tr>
<tr>
<td>Barbell curls</td>
<td>Arms (biceps)</td>
<td>With arms shoulder width apart, hold bar at thigh height, palms facing out. Lift bar to shoulders and return in a smooth continuous movement keeping the back straight.</td>
<td><img src="image5" alt="Barbell curls" /></td>
</tr>
<tr>
<td>Military press</td>
<td>Arms and shoulders</td>
<td>Standing erect and using an overgrip, extend the arms vertically, hold and return to the bent arm position in front of the chest.</td>
<td><img src="image6" alt="Military press" /></td>
</tr>
</tbody>
</table>
Types of resistance training

Strength (resistance) programs can be divided into three categories: isotonic, isometric and isokinetic.

**Isotonic training**

Isotonic strength training is the traditional method of weight training and the most extensively used. During isotonic training, the muscle length changes constantly as the resistance is moved through a full range of motion. This form of training is usually cheap, accessible and easy to learn. However, its biggest limitation is that the resistance does not remain maximal through the full range of movement, so it fails to develop the muscle fibres fully. For example, during the last phase of a biceps curl, momentum rather than muscle strength causes the bar or weight to complete the movement (see figure 14.2). The illustrations in table 14.1 showed isotonic movements.

An exercise prescription for general strength development using an isotonic program is:
- eight to 12 RM
- three to four sets
- slow to moderate speed of exercise
- three days per week
- at least one day between sessions.

**Isometric training**

Isometric training programs are not as popular as isotonic programs, although they do have value. One problem is that isometric gains cannot be measured using isometric equipment, so there is a need for alternative programs, such as free weights, to gauge success.

A typical isometric exercise is pushing against a wall (as shown in figure 14.3) or pulling against an immovable object. Tension develops in the muscle because there is resistance, but the muscle does not shorten since the object will not move. The best gains in strength are made in isometric training programs using six to eight repetitions, each lasting six seconds. Training should occur on four to five days each week. Isometric exercises must be performed at the joint angles where the strength is needed, for example at either the beginning, middle, or end of the contraction. Therefore, the full development of a muscle could require the application of an isometric force at four or five different angles through the range of motion of the joint.

The advantages of isometric training are that:
- equipment needs are minimal
- it is helpful to overcome weaker points (‘sticking points’) in the muscle
- it takes little time, is simple to learn and easy to perform
- it is valuable in rehabilitating an injury, for example a muscle tear
- much can be performed in a variety of places — for example, kitchen or office.

Disadvantages of isometric training are that:
- it does not increase strength through the full range of motion of the joint unless applied at all the respective angles
- it causes a rise in blood pressure
- speed is reduced through strengthening in a static position
- other methods, such as isotonic testing, must be used to measure progress
- it does not produce muscular endurance
- most benefits occur early in training.
**Isokinetic training**

Isokinetic training, though more expensive, is the most beneficial to strength production because it activates the largest number of muscle units.

Sophisticated isokinetic machines automatically adjust resistance according to the force exerted against them. Isokinetic machines use a system of cams to equalise tension through the full range of motion, giving rise to the term ‘accommodating resistance training’.

Isotonic training is very different from isokinetic training in that the level of resistance varies, depending on the joint angle. However, isokinetic training has the advantage of ensuring that strength gains will be constant throughout the full range of movement because the level of resistance offered is constant. Because isokinetic training is expensive and not widely used, its effectiveness has not been fully tested. Additionally, many of the movements performed are not specific to those required in competition. However, it does appear to offer significant strength benefits, particularly in the rehabilitation of injury.

**Figure 14.4:** Using an isokinetic exercise machine

**Application**

**Learning to develop a strength training program**

During this application, work at sub-maximal loads (approximately 50 per cent) to reduce risk of injury while learning to do the exercise. Apply to all exercises. The aim is learning to construct a program, not (at this point) to lift maximal weights. Select three exercises from table 14.1 (pages 434–5). Warm up thoroughly and then perform the exercise until you can establish 1 RM and then 10 RM. Repeat for each exercise. then do three sets of 10 RM for each exercise at slow to moderate speed. Allow a few minutes rest between sets.

**Overload techniques**

Unique overload techniques are sometimes used by advanced weight trainers to stress a particular muscle group in a specific way. During most exercises performed, muscle groups are subjected to a very high level of intensity (resistance). Application of special techniques relating to areas such as joint
angles or muscle isolation is routine. Seven of the more commonly used overload techniques include blitzing, cheating, pyramiding, reverse pyramiding, forced repetitions, super sets and negative repetitions. These are explained and illustrated in table 14.2.

Table 14.2: Overload techniques

<table>
<thead>
<tr>
<th>Overload technique</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blitzing</td>
<td>This is the process of bombarding a specific muscle group with a range of exercises until the muscle is completely fatigued. A variety of exercises is recommended so that all fibres in the muscle are worked as completely as possible and through the full range of motion.</td>
</tr>
<tr>
<td>Cheating</td>
<td>This technique is recommended only for advanced weight trainers. The routine requires assistance from other muscles to help with a lift during the more difficult parts of an exercise. However, while this may aid in performance of the exercise, it might not contribute to good form, particularly if the resistance is excessive. An example would be using the back muscles to straighten the body from a slightly forward position and assist with execution of a biceps curl.</td>
</tr>
<tr>
<td>Pyramiding</td>
<td>Use of this technique requires resistance to be increased with each set until a peak is reached. For example, if the lifter performs five sets of an exercise, the resistance is increased with each set, but the number of repetitions is decreased. As the muscle fatigues, the resistance is lowered with the lifter aiming to complete maximal repetitions.</td>
</tr>
<tr>
<td>Reverse pyramiding</td>
<td>This overload method requires the resistance to be progressively decreased to permit an increasing number of repetitions. Once again, the muscle is worked to fatigue.</td>
</tr>
<tr>
<td>Forced repetitions</td>
<td>Use of free weights fails to stress a muscle group through the full range of movement. This is because the maximum weight that can be lifted is never more than the weakest point of the muscle, often called its ‘sticking point’. Use of forced repetitions helps overcome this. Heavier than normal resistances are used and the services of ‘spotters’ brought in to help lift the weight through the sticking point. This way the muscle can be worked through the full range with very heavy resistances.</td>
</tr>
<tr>
<td>Super sets</td>
<td>This overload technique requires two or more exercises to be applied to a muscle without it having the benefit of a rest period. For example, if the selected muscle was the biceps, curls might be used initially and quickly followed by chin-ups using an under grip.</td>
</tr>
<tr>
<td>Negative repetitions</td>
<td>These are commonly used in advanced weight training. This overload technique requires the use of spotters or assistants to control a weight while it is being lowered. The spotters initially lift a heavier weight than can be pressed to a position upward of the body. They assist as the weight is lowered and the muscle eccentrically contracted.</td>
</tr>
</tbody>
</table>

Training for power and speed

Training for improvement in speed and power relates specifically to the anaerobic system. Development in this area helps athletes to hit harder, jump higher, run faster and throw further. These attributes are required in a range of games, individual sports and all athletic events.
Effects of training on the anaerobic energy system

Resistance training has positive effects on anaerobic energy supply. The anaerobic system, which includes the ATP/PC and lactic acid systems, is the dominant pathway for supply of energy during explosive activities such as weight-lifting, throwing, sprinting and, in general, activities in which power is important. For these events, white muscle fibres are preferentially recruited because they work best in the absence of oxygen. An athlete who trains for anaerobic events using exercises and practices that simulate what is required in the game or activity will further develop the capacity of the fast-twitch fibres. Conversely, research shows that persistent endurance work will deprive the athlete of the ability to realise maximum anaerobic potential; hence the importance of the principle of specificity (see chapter 6, page 165).

Hypertrophy occurs in fast-twitch fibres in response to resistance training. In fact, fast-twitch fibres are more responsive to weight training than slow-twitch fibres and will yield superior results in both muscle size and strength. The closer the similarity between training regimes and the activity (the principle of specificity) the greater will be the adaptations that take place within the fibres. Training needs to be explicit in targeting a particular goal. If the anaerobic system is the intended system for development, the resistance training program needs to apply overload and specificity principles to ensure that most adaptation takes place in fast-twitch fibres.

Power and speed development

Strength training builds power. Because power equals force times distance divided by time, it can be increased by manipulating any one of the three variables — force, distance or time — while keeping the other two constant. For example, power is increased by decreasing the length of time a movement is performed while keeping force (resistance) and distance constant. This equates to performing a movement explosively. Therefore, to increase power using resistance training, movements need to be performed quickly, causing preferential recruitment of fast-twitch fibres.

Strength is a major component of power. This gives rise to the term ‘strength dominated power’, which refers to power in which strength is the dominant ingredient. Starting strength and explosive strength are two important components that influence power development.

Starting strength is the ability to ‘turn on’ as many muscle fibres as possible in the performance of a movement.

Explosive strength is the ability to extend the ‘turned on’ period of explosiveness.
Resistance training for power and speed events

Resistance training programs designed to develop power and speed will seek to enhance fast-twitch fibres involved in the activity. These will be recruited when exercises are performed at speed and closely resemble the movement required in the sport. If the resistance (weight) is too heavy, the exercise will necessarily be performed slowly, leading to recruitment of slow-twitch fibres. A power-dominated resistance training program for a high jumper would address general strength throughout the body, but give particular attention to leg flexion and extension exercises in accordance with the power prescription.

An exercise prescription for power would encompass:

- 5 to 10 RM (resistance 60 per cent to 75 per cent of maximal)
- three to four sets
- fast exercise speed
- five minutes between sets
- three to four days per week.

To develop speed, the resistance is medium to high and the contractions are executed quickly. Movements, although fast, must be rhythmical. By commencing slowly when beginning a program and working on technique, speed techniques can be developed in a smooth, sustainable manner. The principle of specificity to the activity is important. Activities requiring application of explosive forces to propel implements (discus, javelin and shot) will require higher resistances and fewer repetitions during resistance training. Programs designed to develop power and endurance (for sports such as basketball and soccer) require use of moderate resistance, with more repetitions than required for explosive activities. However, there still needs to be emphasis on speed during execution of the movements to ensure appropriate power development.

Resistance training program

Choose any sport or activity. Use a range of exercises similar to those in table 14.1 (page 434–5) to design a resistance training program that develops power/speed as required in a particular sport such as boxing or running. Detail your exercise prescription.

Plyometric training

Gains in strength can be converted to power only by the use of specific training approaches that ‘program’ the muscle fibres to contract quickly. One of the most widely used practices for doing this is plyometrics.

Plyometrics has considerable value in power development because it has been demonstrated that if a muscle is stretched (preloaded) before it is shortened, it will contract more forcefully. The elastic recoil of muscle fibres results in a more powerful movement. In other words, a muscle has the potential to develop maximum tension if it is stretched rapidly and the faster it is forced to stretch, the greater will be the tension that can be applied.

Plyometrics has been used for a number of decades to improve performances in sports such as athletics, basketball, Australian Rules and weightlifting, where the development of reactive power is critical. Exercises that use plyometric type movements use body weight and gravity to instigate the eccentric contraction or ‘cocking’ phase that energises the muscle’s recoil ability. Instinctive use of plyometric principles is seen in athletes such as high jumpers, who lower their

Plyometrics refers to a special range of exercises in which a muscle is lengthened using an eccentric contraction and this is rapidly followed by a shortening or concentric contraction.

An eccentric contraction occurs when the muscle lengthens while under tension. The action often happens with the assistance of gravity.
centre of gravity immediately prior to the jump. Also, a person performing a vertical jump is always observed bending knees and dropping their arms to their sides just prior to the jump. Typical movements used in what is commonly called explosive jump training are standing jumps, multiple jumps, depth-jumps and bounding. Many of these are illustrated in figure 14.5.

Using plyometrics

Using the illustrations in figure 14.5 as a guide, create a plyometric exercise. Following a thorough warm-up, demonstrate your exercise to the class. Then choose the best six exercises to comprise a plyometric program. Run the program with the class.

Plyometrics

Power is developed only when exercises are performed explosively. Some training methods use weighted belts, weighted pulleys or implements such as car tyres to provide resistance to forceful movements. As a class, investigate other methods of developing power and suggest the advantages and disadvantages of each method.

Using power programs safely

Outline the potential dangers of resistance training programs for power and plyometric training. What precautions need to be taken before commencing power programs?
Training for endurance

Endurance training needs to target the aerobic system of energy supply. The principle of specificity is very important, as some endurance events are much longer than others. Endurance training leads to preferential recruitment of slow-twitch fibres. These fibres are red in colour, have a high capillary density and are capable of sustained contraction. Endurance training causes changes to the body’s oxygen transport system, resulting in considerable aerobic and general health benefits.

Effects of training on the aerobic energy system

Endurance training places demands on the body’s ability to deliver oxygen to muscle cells. To this stress, the body gradually responds, making adaptations that allow it to cope better when the same stress is applied once again. Progressively increasing stress is matched by appropriate adaptations, causing the body to vastly improve oxygen delivery, cell functioning and energy transfer. These changes are summarised in table 14.3.

Resistance training for endurance events

Muscular endurance is important in most sports, including middle- and long-distance running and games such as basketball, soccer, netball and touch football. For continuous type movements that form the basis of these activities, the development of maximal power is not an advantage because fast-twitch fibres would be preferentially recruited when slow-twitch fibres are more appropriate.

Effective endurance training requires the use of less resistance and more repetitions than is required for absolute strength training. The level of resistance needs to be not more than 66 per cent of the maximum that can the lifted for each exercise (1 RM). Resistances less than 66 per cent of maximum will result in the type of adaptation in the muscles that will enhance endurance, including:
- larger and more numerous mitochondria in the muscle cells
- increased capillary density, ensuring plentiful oxygen supply to the muscles
- improved aerobic enzyme activity, resulting in better oxidation of fuel.

A general resistance prescription for endurance is:
- repetitions maximum — 15 to 30
- sets — three to four
- speed — moderate
- frequency — three to four days per week.

A prescription for endurance needs to be individualised, and should specifically address the sport or activity. This is particularly relevant to the number of repetitions required. As the number of repetitions is raised, strength will decrease and endurance increase. If training for long-distance events, use of lighter weights and many repetitions is appropriate. However, if training for shorter events such as a 400- or 800-metre run, anaerobic threshold training needs to be combined with resistances in the order of 15 to 25 RM.
### Table 14.3: The effects of training on the aerobic energy system

<table>
<thead>
<tr>
<th>Area</th>
<th>Effect</th>
<th>How this improves training</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel storage and utilisation</td>
<td>Increased haemoglobin</td>
<td>More oxygen is carried to the working muscles.</td>
</tr>
<tr>
<td></td>
<td>Increased myoglobin</td>
<td>More oxygen is delivered from the cell membrane to the mitochondria where fuel is burnt.</td>
</tr>
<tr>
<td></td>
<td>Increased ability to use fat</td>
<td>The reserve fuel can be used earlier in endurance events.</td>
</tr>
<tr>
<td></td>
<td>Increased storage of ATP and CP</td>
<td>Immediate fuel storage is increased up to 25 per cent.</td>
</tr>
<tr>
<td></td>
<td>Increased glycogen storage</td>
<td>Fuel for lactic acid and aerobic systems is increased.</td>
</tr>
<tr>
<td></td>
<td>Increased ability to use glucose</td>
<td>Increased enzyme activity enables faster breakdown of glycogen.</td>
</tr>
<tr>
<td>Oxygen transport system at rest</td>
<td>Increased heart size</td>
<td>This is particularly evident in size of left ventricle, making more blood available per beat.</td>
</tr>
<tr>
<td></td>
<td>Decreased heart rate</td>
<td>This is a sign of increased heart efficiency, as it is able to supply the required blood with less beats/minute.</td>
</tr>
<tr>
<td></td>
<td>Increased stroke volume</td>
<td>More blood is available per stroke.</td>
</tr>
<tr>
<td></td>
<td>Increased cardiac output</td>
<td>More blood is available to tissues.</td>
</tr>
<tr>
<td>Oxygen transport system at maximal exercise</td>
<td>Increased oxygen uptake</td>
<td>There is an increased ability of muscles to extract and use the oxygen being delivered in the blood.</td>
</tr>
<tr>
<td></td>
<td>Increased cardiac output</td>
<td>More blood is available to tissues.</td>
</tr>
<tr>
<td></td>
<td>Increased stroke volume</td>
<td>More blood is available per stroke.</td>
</tr>
<tr>
<td>Respiration</td>
<td>Increased efficiency</td>
<td>More oxygen is extracted from air to alveoli and delivered to muscles.</td>
</tr>
<tr>
<td>Other</td>
<td>Increased muscle size</td>
<td>This produces more strength.</td>
</tr>
<tr>
<td></td>
<td>Decreased body fat</td>
<td>There is less excess to carry in endurance events.</td>
</tr>
<tr>
<td></td>
<td>Increased strength and power</td>
<td>Produces faster, more forceful movements.</td>
</tr>
<tr>
<td></td>
<td>Increased muscle elasticity</td>
<td>There is increased muscle power and less likelihood of injury.</td>
</tr>
<tr>
<td></td>
<td>Increased mitochondria</td>
<td>There are more sites on muscle fibre for burning fuel.</td>
</tr>
</tbody>
</table>

### Application

#### Developing a resistance program for endurance

Using some of the exercises in table 14.1 (pages 434–5), develop a resistance program for a sport or activity in which considerable endurance is required. Include exercises, sets, repetitions, speed and rest. Following a thorough warm-up, test your program by performing it in the prescribed manner.

### Measuring training effects

The effect of an endurance training program can be measured using one or a number of recognised tests. Many high-profile fitness establishments now have laboratory equipment that accurately measures **maximal oxygen uptake**. During these tests, subjects are required to run on a treadmill or use a cycle ergometer or similar device to establish intensity. The oxygen used as the subject exercises to maximal capacity is calculated by examining the difference between the oxygen content of air inhaled and that exhaled. Elite endurance
runners have high maximal oxygen uptake values, since their oxygen delivery systems have adapted to the demands of endurance training.

Because sophisticated laboratory testing is both expensive and time consuming, sports trainers often use sub-maximal tests such as the bicycle ergometry test which predicts maximal oxygen uptake using sub-maximal workloads. In schools, where large groups need to be tested and equipment may be in short supply, use of field tests such as the Balke 15-minute run, Cooper’s 12-minute run or the multistage fitness test are commonly used to establish maximal oxygen uptake. While sub-maximal tests and field tests are never completely accurate because they rely on other factors, such as motivation, they are relatively reliable at determining the level of maximal oxygen uptake in individuals. The multistage fitness test is one such test and is outlined below.

**Application**

**Participating in a test of maximal aerobic power**

**Equipment**

Cassette or CD player, multilevel fitness test tape or CD, firm surface with two lines marked 20 metres apart.

**Procedure**

1. Form a group of no more than 10 subjects to one supervisor.

2. Divide the group into two. Half the group is to perform the test while the remaining half observes and records the results.

3. Use a general purpose warm-up, including leg stretching exercises, before commencing this test.

4. The subjects in group one should move to the start line and listen to the introductory remarks on the tape or CD, which tell them when to start and how to judge pace.

5. Subjects begin by walking to the end line, aiming to reach it on the ‘beep’. Both feet must cross the line. They then turn and walk back, aiming to reach the start line on the next ‘beep’. Gradually the tempo is increased, necessitating a jog and then a run to reach the other line by the sound of the ‘beep’. When subjects fail to stay in time with the ‘beep’ they are given a warning. Failure to catch up or a second warning means the subject must stop the test.

6. Record the level at which the subject is unable to continue and note the oxygen uptake in the table below.

<table>
<thead>
<tr>
<th>Table 14.4: Oxygen uptake according to levels</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Level</strong></td>
</tr>
<tr>
<td>-----------</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>5</td>
</tr>
<tr>
<td>6</td>
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<tr>
<td>7</td>
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<tr>
<td>8</td>
</tr>
<tr>
<td>9</td>
</tr>
<tr>
<td>10</td>
</tr>
</tbody>
</table>
7. Visit the website for this book and click on the VO₂ Max weblink for this chapter (see ‘Weblinks’, pages x–xi). Insert your oxygen uptake (VO₂ max) reading and calculate your fitness assessment for your age group.

### Examining the test

Discuss why the test is a maximal test. Examine your results and rating. Discuss whether they reflect your current fitness level and suggest factors that may have influenced the reading.

### Training for flexibility

**Flexibility** training requires that muscles stretch or lengthen safely. Muscle strength and muscle length are both directly related to the number of muscle fibres engaged. Just as muscle contraction is more forceful if many fibres are engaged, the total length of a stretched muscle is proportional to the number of fibres stretched. When a muscle is stretched, some fibres lengthen while others remain at rest. The more muscle fibres that are stretched, the more length will be developed by the muscle for a given stretch.

All stretching movements need to be safe. The body has an in-built safety mechanism called the *stretch reflex* (see chapter 6, page 179) to warn about elongating fibres beyond safe limits. When the muscle is stretched, so is the muscle spindle, which then acts to register changes in length of the fibre. The message is sent to the central nervous system (CNS), which activates the stretch reflex. This unit responds by causing the stretched muscle to contract. The more abrupt the change in muscle length, the more forceful will be the muscle contraction. This mechanism helps to protect the body from injury. Safe flexibility exercises require stretches to be slow, controlled and sustained for periods of time. This allows the muscle spindle to become accustomed to the new length and, as a result, reduces its signalling to the central nervous system. Stretching on a regular basis is advocated to progressively teach stretch receptors to allow greater lengthening of the stretched muscles.

### Types of flexibility

Broadly, there are two different types of flexibility. Flexibility involving motion is called **dynamic flexibility** while flexibility characterised by absence of motion is called **static flexibility**.

Static flexibility can be active or passive. **Active flexibility** is more closely related to sport skills than **passive flexibility**, but it is more difficult to develop. Active flexibility requires not only passive flexibility in order to assume a stretched position but also muscle strength to be able to retain that position.
There are four common types of stretching exercise used in flexibility programs. These are:
- static
- ballistic
- proprioceptive neuromuscular facilitation (PNF)
- range of motion (ROM).

**Static stretching** is commonly used because it is safe and does not require the use of equipment. The movement is smooth and is performed slowly, taking the muscle to a point where there is stretch without discomfort. Static stretching is used extensively in the rehabilitation of injury and the warm-up and cool-down phases of training. An example of a static stretch would be sitting down with legs extended and gently reaching forward to hold toes (without bouncing).

**Ballistic stretching**, often called dynamic stretching, involves repeated movements such as swinging and bouncing to gain extra stretch. It should be practised only by elite athletes, and with care.

**Ballistic stretching** is used in preparation for athletic events in which explosive movements are required. Ballistic tasks involve activities such as hurdles, boxing, high kicks in aerobic competitions and certain movements in gymnastic routines.

Ballistic stretching is potentially dangerous as it activates the stretch reflex that prevents muscle fibre damage through overstretching. For this reason, ballistic stretching should be used only by advanced athletes and even then should follow a thorough warm-up and another form of stretching. The movements must be controlled and executed rhythmically to avoid jerky actions and excessive momentum at the end point of the stretch. Violent ballistic stretching causes micro-tears in muscle fibres, weakening the tissue or even rupturing the muscle or tendon. An example of ballistic stretching would be touching toes using a bouncing motion, as illustrated in figure 14.9.

**Figure 14.9:** Touching toes using a bouncing motion is an example of ballistic stretching. It should be used only by elite athletes under supervision as it can damage muscles through overstretching.
Another type of stretching is proprioceptive neuromuscular or PNF stretching. This became popular in the 1960s following attempts by physiotherapists to rehabilitate muscle injury.

The procedure for doing a PNF stretch is as follows.
- Determine the muscle group to be stretched.
- Stretch the muscle using a static contraction.
- While stretched, apply an isometric contraction and hold for 6–10 seconds.
- Relax for five seconds.
- Repeat the process, stretching a little further than previously.

PNF stretching is useful in rehabilitation programs because the isometric component strengthens the muscle fibres during the stretching process. PNF is also recommended as an integral part of the warm-up and cool-down phases of training programs because of its ability to provide added stretch under safe conditions. Refer to the figure below for examples of PNF stretches.

Range of motion (ROM) stretching is popular in exercise classes, team sports and as an interim phase between static and ballistic stretching. Examples of ROM stretching are arm circling prior to bowling in cricket and butterfly swimming.

Flexibility and performance
Flexibility is affected by a number of factors including:
- **age** — muscles shorten and tighten with age
- **gender** — generally speaking, females are more flexible than males
- **temperature** — increased temperature, both atmospheric and body, improves flexibility
• **exercise** — people who are frequently involved in exercise are usually more flexible than sedentary people

• **specificity** — flexibility is joint specific. The fact that a person is flexible in the shoulders does not automatically mean similar flexibility exists in the hips.

To improve flexibility and its specificity to performance, it should be remembered that:

- dynamic flexibility is best increased by doing dynamic stretches and supplementing with static stretches
- active flexibility is best increased by doing active stretches and supplementing with static stretches
- passive flexibility is best improved by performing PNF stretches.

A flexibility training program needs to be conducted with certain guidelines in mind. These include:

- performance of a safe stretch program on at least three to four occasions per week
- ensuring muscles are warmed up before stretching
- stretching no further than the muscles will go without pain
- not aiming at excessive flexibility, as this causes joint instability and increased risk of injury.

Team sports such as football, basketball, netball and hockey can cause muscle tightness and shortening because the muscles do not experience the full range of movement. Stretching during the warm-up and cool-down phases can promote the flexibility that will assist these activities. The overload principle applies equally to flexibility training. In other words, the muscle must be stretched beyond its normal length (by approximately 10 per cent) to cause changes to take place, that is, to increase flexibility. Table 14.5 illustrates some stretching exercises that could comprise a flexibility program for sprinting.

**Table 14.5: Stretching exercises for a sprint training program**

<table>
<thead>
<tr>
<th>Stretch</th>
<th>How performed</th>
<th>Illustration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quadriceps stretch</td>
<td>Clasp the foot first with one hand and pull the foot towards the buttocks. Keep knees close together. Do not arch the back or flex the hip. Tilt the pelvis posteriorly and shift the front of the thigh forward. Do not flex at the hip. Repeat with other foot.</td>
<td><img src="image" alt="Quadriceps stretch illustration" /></td>
</tr>
<tr>
<td>Hamstring stretch</td>
<td>Standing, let the knees bend as you touch your toes. Now straighten one, then the other. Do not bounce. Now cross the legs and repeat to stretch both hamstrings.</td>
<td><img src="image" alt="Hamstring stretch illustration" /></td>
</tr>
</tbody>
</table>
### Table 14.5: (continued)

<table>
<thead>
<tr>
<th>Stretch</th>
<th>How performed</th>
<th>Illustration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adductor stretch — sitting</td>
<td>Sit with soles of feet together and with the elbows resting on the inside of the knees. Gently counter-resist on the knees, then relax and let the legs stretch closer to the floor.</td>
<td><img src="image1" alt="Adductor stretch illustration" /></td>
</tr>
<tr>
<td>Calf stretch</td>
<td>Leaning against a wall, lift the arch of the foot slightly. Keep the hip and the knee in a straight line and lean forward. Stretch each leg separately. Do not let the arch collapse to a flat-footed position as you do this stretch, as this may cause overstretching of ligaments in the foot.</td>
<td><img src="image2" alt="Calf stretch illustration" /></td>
</tr>
<tr>
<td>Achilles and soleus stretch</td>
<td>Leaning against a table, lift the arch of the foot slightly. Keep the hip and the knee in a straight line and lean forward. Now bend the knee to stretch the Achilles tendon and soleus.</td>
<td><img src="image3" alt="Achilles and soleus stretch illustration" /></td>
</tr>
<tr>
<td>Advanced hip stretch</td>
<td>In the cat stretch position, place one leg at 45 degrees to the body over and behind the other leg. Place the top of this foot to the floor. Let body weight gently stretch into the hip of the bent leg. Do not collapse to the floor.</td>
<td><img src="image4" alt="Advanced hip stretch illustration" /></td>
</tr>
<tr>
<td>Hip abductor stretch</td>
<td>Place the leg to be stretched behind the toes eight to 10 centimetres away from the opposite heel. Turn the toes of the behind leg inwards 30 degrees and let body weight fall into this hip. You may need to rest on heels to get a more effective stretch.</td>
<td><img src="image5" alt="Hip abductor stretch illustration" /></td>
</tr>
</tbody>
</table>

(continued)
### Table 14.5: (continued)

<table>
<thead>
<tr>
<th>Stretch</th>
<th>How performed</th>
<th>Illustration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latissimus dorsi stretch</td>
<td>Sit with one leg bent and the foot just resting against the inside of the opposite thigh. Place the opposite hand on this leg then bring the other hand over and reach towards the outstretched leg. Clasp the outside of the ankle, look under the elbow and pull up to stretch the side of the trunk.</td>
<td><img src="image1" alt="Illustration" /></td>
</tr>
<tr>
<td>Triceps stretch</td>
<td>Put one hand up and behind the neck and resist against the other hand which is placed on the back of the wrist. Point the elbow to the ceiling.</td>
<td><img src="image2" alt="Illustration" /></td>
</tr>
<tr>
<td>Knee hug stretch</td>
<td>This is for the hip, gluteus maximus and lower back. Pull one knee up on to the chest. Progress to bringing the forehead to the knee. Advance by keeping the outstretched leg off the ground as you stretch each leg. This will strengthen the abdominals as you stretch the hip extensors.</td>
<td><img src="image3" alt="Illustration" /></td>
</tr>
</tbody>
</table>


### Developing a flexibility program

Using table 14.5 as a guide, design a flexibility program for your favourite sport or activity.

### Contraindications for flexibility training

While realising the enormous benefits of flexibility training, some movements commonly used are **contraindicated**. Rather than attempt to learn which exercises are potentially harmful, it is more expedient to become familiar with principles or rules that, when applied, indicate the ‘safeness’ or otherwise of an exercise. While there are many exercises to choose from that will increase the range of motion throughout a joint, choices need to be made carefully. Some may be dangerous or ineffective because they are incorrectly executed. Many contraindicated movements have been practised widely for years. Unfortunately, in many cases, we have only become aware of the dangers involved once the damage has been done. Contraindicated exercises include movements causing **hyperextension**, **hyperflexion**, **excessive twisting** and **joint impingement**.

Extreme movements that cause hyperextension of the neck, lower back and knee should be avoided as they can cause:
- pinched nerves
- disc compression
- squeezed arteries
- lower back strain
- overstretched ligaments.

Examples of exercises that cause hyperextension are shown in figure 14.11.

**Figure 14.11:** Movements that cause hyperextension

Extreme movements that cause hyperflexion to the knee, neck or lower back are to be avoided as they can cause:
- stretched ligaments resulting in loosening the joint capsule
- possible damage to cartilage
- irritation to disks.

Examples of exercises that cause hyperflexion are illustrated in figure 14.12.

**Figure 14.12:** Exercises that cause hyperflexion

Excessive twisting movements should also be avoided as they can cause:
- strain to the knee ligaments
- loosening of the knee capsule.

Examples of exercises that cause excessive twisting are illustrated in figure 14.13.

**Figure 14.13:** Exercises that cause excessive twisting
Movements that cause joint impingement are contraindicated, as they can cause:
- muscle strain
- joint compression and resulting nerve impingement.

A commonly used exercise that can cause joint impingement at the shoulder joint is long arm circling with palms remaining down. This is illustrated in figure 14.14.

![Figure 14.14: Long arm circling with palms down](image)

Attempting to achieve excessive flexibility can also cause harm to body structures. Once a muscle has attained its maximum length, attempting to stretch it further will result in damage to ligaments, tendons or both. Ligaments tear when stretched beyond 6 per cent of their normal length, whereas tendons are basically inelastic. Excessive stretching causes muscle trauma and results in joint instability, which heightens the risk of injury.

**Training for skill and improvement**

An effective coach will plan sessions that generate enthusiastic participation by players and appropriate progressions through the different stages of learning. This involves using a number of techniques to make practice that is challenging and enjoyable and to maintain motivation.

**Variety of practices/drills**

Players learn physical skills through repetition of movements in what are called *skills practices or drills*. The players need to grasp a mental picture of the skill through demonstration/video and be made aware of the important points in learning the skill (teaching points). During a skills practice, the player focuses on executing the skill as correctly as possible. There will be errors in the initial stages but, with practice, feedback and refinement, the player will gradually improve.

It is important to have a variety of skills practices for teaching a particular skill or combination of skills. Skills taught repeatedly under the same conditions and using the same situations will not challenge players and will lead to loss of interest and motivation. Effective coaches plan their drills and illustrate them on paper for quick reference. An example is shown in figure 14.15. Skills practice...
can be varied by changing the complexity of the activity, concentrating on one or more skills, using a real game or small-side games and by changing group organisation (for example, individual, pair, grid work). Some of the possible variations are listed below.

- **Individual skill development.** A basic skill, such as dribbling in soccer, can be practised in pairs or small groups to gradually provide simple-to-complex skill development. The same skill can be continually modified by the coach to include a number of variables such as speed, increased control, linking with another skill, passive opposition and full opposition.

- **Minor games.** These are fun games often organised on smaller modified areas of play, but requiring the use of the same skills as the real game. These games can be used to focus on particular skills and provide the opportunity for players to have repetitive practice of techniques. Minor games add fun and enjoyment to a training session. Examples include end ball and corner ball for basketball and netball.

- **Phase practice.** This involves the repetitive practice of a specific part of the game under competitive game conditions — for example, passing into the circle in netball and positioning for a corner in hockey. The emphasis is on repetition and improvement of a skill or strategy in a particular situation. This practice may be performed with or without opposition — for example, a three-on-one drill.

- **Functional practice.** These practices are designed to improve the skill of a particular player or group of players who have a special function in the game — for example the forwards in rugby union or shooters in netball. They could be designed specifically to make use of particular players’ strengths or improve weaknesses, and be practised with or without opposition (see the case study on page 454).

- **Small games.** These are games that resemble the major game but have a smaller number of players — for example, three-on-three basketball or five-a-side hockey. They are played under game conditions and provide the opportunity for all players to be involved continuously. They can provide both skill practice and fitness. Small games can also be used to impose certain conditions (conditional games) on the play in order to practise a particular skill; it might require, for example, that all shots at the basket must be jump shots.

### Developing a skills practice

Using a game of your choice, develop a drill that can be used for learning a particular movement such as a lay-up in basketball or tackle in football. List teaching points and illustrate player movements using a legend, like the one shown in figure 14.15. Present your skills practice in small groups.

### Analysis of technique

Effective coaching requires skilful observation of performances, analysis and the provision of feedback to the players. This information can then be used to improve performance, detect faults or determine the cause of the poor performance. To begin skilful observation and analysis, the coach must focus his or her observation on a specific aspect of execution. This involves breaking the skill down into observation phases; for example, in a tennis serve the coach would divide the performance into grip and stance, back-swing, toss, impact and follow-through.
Productive observation requires development of a trained eye. Looking may involve watching repeated performances (possibly on videos using slow motion) until sufficient evidence is available to confidently identify strengths, faults and deficiencies in the performance. When viewing the performance the coach initially concentrates on large, slow movements, then on the smaller/faster movements. Often the coach needs to watch and consider rather than always comment on the performance immediately.

**Technique correction**

Technique correction is necessary where skill execution has a fundamental flaw. Coaches need to be aware that all players will not necessarily perform a skill in exactly the same manner. One has only to observe elite sportspeople to see a range of techniques applied to serving a tennis ball, swinging a golf club or swimming. These occur because of differences in player height, weight and mechanics. However, corrections will be essential if the manner in which the skill is being executed can be improved or if the current technique is undermining performance.

**CASE STUDY**

**Improving agility in netball**

Analysis of the volume, intensity and variety of movement netball demands reinforces that it’s a game played at high speed with many sudden changes of direction.

Players can spend up to 13 per cent of a match shuffling in a sideways direction at full pace and effort.

The time spent shuffling ranges from 1.3 to 1.9 seconds, depending on the position played, with an average of 300 shuffle movements performed each game.

The ability to change direction at speed is called agility. Incredibly, players may change direction more than 2000 times a game. Add to this equation the responsive movements of a player’s opponent and it is little wonder that many novice fans forget netball is meant to be a non-contact sport.

Amid the high-speed chaos that such movements create are the ‘good drivers in heavy traffic’. Those players are so elusive that they always seem to get free of their opponent to receive a ball in space . . .

One of the common methods of measuring the agility qualities of athletes is to require them to run around a series of cones in a predetermined movement pattern as quickly as possible.

This type of test reflects the movements of attackers who know where they want to run. Usually, when the elite are compared to lesser-skilled players, elite players are found to be faster in completing the movement pattern.

However, one only has to watch team sport to realise that it’s more common to see situations where an agility pattern is not pre-planned but rather a player’s agility relies on reacting to the movements of the opposition and calls of teammates.

In recent times, sports scientists have tried to replicate this type of agility to better reflect the qualities of those ‘good drivers in heavy traffic’.

Through the use of near life-size video projections of the movements of a virtual opponent, netballers at the Australian Institute of Sport have had their reactive agility examined.

The players are required to complete a shuffling pattern as if defending an opponent. While completing this movement, the players watch the virtual opponent on the life-size projection receive a ball and prepare to pass it off to a teammate. The player being tested is required to intercept the ball by changing direction and then springing in the anticipated pass direction.

Results of such testing have revealed that the more agile players really stand out on the reactive test relative to a planned agility test.

The reason for the clearer differences between the skill levels on the reactive test can be attributed to the anticipatory ability of the players. While lesser-skilled players waited for the virtual opponent to release the ball before changing direction, elite players anticipated the pass direction based on the posture of the player and hence changed direction before the ball had been released.

This quick decision allowed the player to get the jump on their opponent . . .

**Source:** Damian Farrow and Justin Kemp, ‘Netball, where agility is king and a shuffle is always on the cards’, in The Age, 20 November 2004.
Case study: improving agility in netball

Read the case study ‘Improving agility in netball’ and answer the following questions.

1. What is the definition of ‘agility’?
2. What is a common method of measuring an athlete’s agility?
3. During an actual game, to what does a player need to react?
4. Explain how netballers at the Australian Institute of Sport have had their reactive agility examined.
5. What did the tests reveal about the abilities of skilled netballers?

Training to improve performance

Draw and complete a web or bubble map (see page 33 for an example) to summarise responses to the critical question ‘How do athletes train to improve performance?’

HOW COMPETITION AFFECTS PERFORMANCE

Success in any competition requires careful planning, organisation and commitment. Because there will be considerable variation in time and effort required for preparation and performance, the training year is normally divided into phases.

Phases of competition

There are three phases of competition: the preparation phase (pre-season), competition phase (in-season) and transition phase (post-season).

Preparation phase (pre-season training)

This phase might last from six to 12 weeks or longer, depending on the type of competition. It will require a high volume of training at moderate levels of intensity. This needs to target the appropriate energy system. As a result, training sessions will be longer in an effort to increase stamina together with mental aspects such as increasing drive and commitment. The basic aim of the preparation phase is to:

• improve all aspects of fitness, such as strength and flexibility, and particularly those specifically required in the sport
• develop technique
• improve performance biomechanics
• introduce strategies and familiarise players with them
• teach appropriate mental skills.

These aims are best achieved through programs that focus on endurance, strength and skill in a variety of environments. Examples of commonly used methods include:

• continuous training
• Fartlek training
• interval training
• circuits
• resistance work
• variations of long slow work with short fast work.
Important fitness components such as speed, strength and flexibility need to receive specific attention. Towards the end of the preparatory phase, the level of physical condition and quality of skill performance (for example, technique, biomechanics and strategies) should be high.

**Competition phase (in-season training)**

The competition phase will vary in duration, depending on the sport. During this phase, maintaining fitness developed in the preparation phase is continued. However, a general increase in intensity is matched by a corresponding decrease in volume. In other words, less time will be spent on continuous repetitive work but the effort put into training will escalate. The aim during this period is to:

- maintain stamina
- practise and improve tactics and strategies
- perfect skill execution
- gain competitive experience
- continue work on developing appropriate mental skills.

This is best achieved through:

- supplementary work on required fitness components, including strength, power, agility, flexibility and speed
- use of highly specific skills practices (drills)
- continuation of conditioning training
- use of small games, grids and resistance work to increase intensity and provide relief.

The principle of specificity needs to be applied more rigidly during the competition phase. The gradual increase in intensity should be matched by focus on activities that relate directly to competition requirements. Specificity needs also to be applied to the mix of volume and intensity. For instance, in power sports requiring explosive actions such as sprinting and high jump, some volume will be sacrificed at the expense of increased intensity. However, in endurance activities such as cross-country running and triathlons, the volume remains steady.

The number of training sessions required will vary in accordance with the type of activity. This will relate to the athlete’s ability to *load* (train) and *unload* (regenerate). Excessive emphasis on work without ample time for restoration will lead to development of a state known as *overtraining*. The competitive phase will have many periods in which volume and intensity are manipulated to provide the greatest gain. However, it is important that the athlete peaks for each competition and particularly for major events within the season.

**Transition phase (off-season training)**

This phase is one of physical and mental recovery from training and competition. It provides time for general refreshment, allowing both mental and physical abilities to recuperate. It is sometimes thought that off-season training means absence of all activity. This is incorrect, as a complete lay-off will lead to a loss of the immense gains made during training and make the pre-season preparation more difficult and protracted.

The transition phase is characterised by:

- one week of total rest
- remaining weeks consisting of active rest, with training sessions being reduced to a couple of times per week and a corresponding reduction in both volume and intensity
• a change in environment, such as outdoors to indoors or use of swimming for runners and cyclists
• diet modification to reflect the decreased workload
• maintenance of strength and flexibility
• work on weaknesses, such as injuries, or perhaps on specific technical skills.

The value of the transition phase should not be underestimated in terms of refreshing the athlete. Although it is generally a short period lasting a month or so, it provides the opportunity to restore mental and physical energy and prevent the onset of staleness in the coming competitive season. A plan for development and maintenance of strength, endurance and speed is illustrated in figure 14.17.

<table>
<thead>
<tr>
<th>PREPARATORY</th>
<th>COMPETITIVE</th>
<th>TRANSITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>General preparatory</td>
<td>Specific preparatory</td>
<td>Pre-competitive</td>
</tr>
<tr>
<td>Strength</td>
<td>Anatomical adaptation</td>
<td>Maximum strength</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Endurance</td>
<td>Aerobic endurance</td>
<td>Develop the foundation of specific endurance</td>
</tr>
<tr>
<td>Speed</td>
<td>Aerobic and anaerobic endurance</td>
<td>Develop the foundation of speed</td>
</tr>
</tbody>
</table>

Figure 14.17: The development of specific attributes during the phases of competition (Source: TO Bompa, Theory and Methodology of Training, 3rd ed, Kendall Hunt, 1994, Dubuque, Iowa, p. 251.)

Peaking is the phase of training in which performance is optimised to meet the demands of a race, competition or series.

Tapering is a period immediately before competition when the volume and intensity of training is reduced.

Peaking for performance

To arrive at a point at which an athlete peaks will usually involve months of preparation, gradual increases in volume and intensity of training and a short tapering period (see page 458) just prior to performance. For example, a marathon runner will train for four to six months, and this will involve periods of base building (no speed work), sharpening (which requires specific endurance), speed work and finally a tapering phase approaching the peak. The training program needs to be organised so that physical and mental functioning is optimised at the right time. The peaking period is actually a temporary state that is reached only during the competitive phase of training. When this occurs, a number of physiological indicators will be apparent, including:
• a state of excellent health
• heightened rate of recovery from training
• body systems, particularly the circulatory, respiratory, muscular and energy systems, tuned for optimal functioning
• adjustments to technical and tactical preparation completed
• superior neuromuscular coordination.

The athlete during the peaking phase is also characterised by a number of social and psychological indicators including:
• heightened self-confidence and motivation
• an ability to tolerate higher levels of frustration and react positively to practices that simulate the competition environment
• a state of mental alertness and readiness for action.

**Tapering**

Concentrated training with increasing volume and intensity reduces strength and subsequently impacts on performance. A tapering period is fundamental for allowing tissue to rebuild and for the full replacement of energy stores.

Tapering is essential because intense training, while having numerous positive benefits, has an adverse effect on some aspects of performance. While the manner in which athletes taper will vary from one sport to another, it must involve a reduction in volume and intensity to be effective. It is now known that the tapering period that follows a quality preparation will bring about an increase in the strength and power of the athlete. However, this will be more pronounced in swimmers and less obvious in runners. Research shows that runners and swimmers who reduce training by 60 per cent for a 15- to 21-day period show no loss in maximal aerobic capacity. More importantly, swimmers tested experienced a 3.1 per cent improvement in performance as a result of reduced training and demonstrated a 17.7 per cent to 24.6 per cent increase in arm strength and power.

**Success or failure: it’s all a matter of timing as athletes chase perfect taper**

Read the snapshot ‘Success or failure: it’s all a matter of timing as athletes chase perfect taper’. Discuss the importance of tapering and suggest how tapering programs differ for:
- swimming
- track
- team games.

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**SNAPSHOT**

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Success or failure: it’s all a matter of timing as athletes chase perfect taper

By Martin Blake

Shane Kelly remembers it only too well. Kelly came to the world track cycling championships in Melbourne in May 2004 ill-prepared for the level of competition he was about to confront.

He was performing in front of his home crowd ... with family and friends at Vodafone Arena. And, of course, there was the expectation of simply being Shane Kelly, one of Australia’s greatest cyclists ever.

But he missed a medal in his favourite kilometre time-trial, an event in which he is a triple world champion. It was the first time since 1992 he had not been in the medals in the event — by Kelly’s high standards, a dramatic flop.

The reason? It was an Olympic year and Kelly didn’t have his taper right for the worlds, which were a month or so earlier. ‘I would have loved to have done my best,’ he said last week. ‘But I had to push that aside because the Olympics were the big one. That’s how I had to take it.’

Tapering, the art of tailoring your practice to produce optimum performance on the right day, has
been around for years. Bart Cummings does it with horses and has 11 Melbourne Cups to show for it and sporting coaches have been trying to do the same thing with varying success.

In broad terms, it’s about doing the hard slog a long way out from a major event, then tapering off as it draws closer. This process may happen several times inside the same year. But it varies from athlete to athlete, depending upon how they react to their periods of hard training and their recovery rate. Nowadays sports scientists talk about a ‘supercompensation’, where a tired athlete’s body gets an enormous boost from a period of rest, as though the body is expecting more of the same hard work. Ideally, this is when they compete in a major event.

The coaches and athletes don’t necessarily know if they are getting it right. But they are clear on one point: it’s crucially important . . . In three major sports to be contested at the Commonwealth Games — swimming, track cycling and athletics — the national titles have been held in the past few weeks. This presents the coaches and athletes with a different problem: how to get their athletes ‘up’ twice in a short space of time . . .

For the first time this year, Swimming Australia programmed the selection trials only a month out from a major event. Previously, there has been a gap of a few months. It’s a product of the packed international schedule, but it did not necessarily please the coaches. ‘It’s a challenge,’ says Bernard Savage, Swimming Australia’s head of sports science.

Freestyler Libby Lenton and breaststroker Jade Edmistone also broke world records in their events at Melbourne and will go through the same process. Savage said they undoubtedly would be flat for a while before ramping up the intensity. ‘We’re still a month out, so I would say those swimmers would have a solid week of training next week,’ says Savage. ‘After that, they might back off a bit. But they can’t just expect to float into the Commonwealth Games from the trials. They’ll lose too much condition if they do that.’

Coaches are fanatical about it, so much so that when Stephan Widmer, coach of Jones and Lenton, had his log books stolen from his car recently, he was mortified.

Alan Thompson, the national swimming coach, says his sport has never found definitive answers to the riddle. Thompson quotes figures that suggest only 50 per cent of personal-best times in swimming have come in Olympic finals.

‘That’s about the average,’ he said. ‘We never get on top of it. You can buy plenty of books on anything and plenty on swimming. But you can’t buy one on tapering. You try certain things with some athletes and then you can do the same thing with the same athlete on a different occasion and get a completely different result.’

Troy Flanagan, head of sports science at the Victorian Institute of Sport, confirms the suspicion that it is a field that is far from fully explored. ‘Coaches are still using trial and error,’ says Flanagan. ‘There’s a real art to it and the rate of personal-best times in Olympic finals is still very low. Considering you have four years to get it right, the strike-rate should be higher. But there’s so much that is not known about the human body.’

The notion that an athlete can reach a certain level of expertise and hold it year-round is bunk. Kelly says: ‘You can hold a certain competitive level all year. But at your absolute best in my event, I reckon it’s twice a year. If possible, I’d prefer to focus on one a year.’

Flanagan says technology may eventually provide the answers. At the VIS, swimmers have been using a mobile sports science unit that uses blood samples to measure variables and levels of fatigue.

‘We’re only beginning to understand all this but with this type of technology, I think we’re going to get better,’ says Flanagan.

Thompson is not necessarily convinced. ‘Everyone’s got their thoughts and how far down you have to take an athlete and it varies with the coaches. The problem is, we can’t hit one nail on the head and say, “This works”.’


Dietary considerations
An appropriate diet is most important for all athletic performance, particularly endurance performance. While those involved in activities of short duration such as sprints and throws have no additional energy or fluid needs beyond that provided by a normal diet, those involved in sustained activity need to be aware of appropriate fluid requirements and additional energy that may be
needed. The following dietary guidelines are suggested for athletes preparing for endurance competition. (Note that information on gender considerations, and hydration and fluid replacement can be found in chapter 13, pages 399 and 411.)

Pre-game meal
The following guidelines are suggested for eating before an event.
- Food should be consumed three to four hours before competition in the case of a large meal, and one to two hours before in the case of a snack.
- Intake should basically consist of complex carbohydrates (whole cereals, whole bread, fruits), as these provide a sustained source of energy.
- Avoid foods high in fat and protein (meats, for example), as these take longer to digest.
- Avoid foods high in simple sugars, as the energy supply will be deficient.
- Maintain adequate fluid levels. In extended events such as marathons, continuous replacement is necessary.
- ‘Liquid meals’ (drinks with a high carbohydrate content) are recommended if solid meals are difficult to digest. Correctly prepared, they can be an adequate source of nutrition and energy, and contribute significantly to hydration.

Finally, it is important to realise that patterns for pre-game eating need to be established over a period of time and new foods should not be added to the diet without a trial period.

During competition
In endurance events, there may be a need for carbohydrate supplements to avoid glycogen depletion. Exercise physiologists generally agree that some liquid glucose consumed during endurance events will help ‘top up’ glycogen and may deter or prevent hypoglycaemia. During endurance events it is essential to:
- maintain adequate hydration by regular fluid intake
- not wait until thirst develops before drinking fluid.

Suggested fluid intake is illustrated in figure 14.19.

**Figure 14.18:** Examples of sports drinks that may help athletes during and after competition

**Figure 14.19:** Suggested fluid intake before, during and following competition

<table>
<thead>
<tr>
<th>Before competition</th>
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<tr>
<td>• At least 500 mL, 30 minutes prior to competition</td>
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<th>During competition</th>
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<td>• Drink 200 mL every 15 minutes; do not wait for thirst to develop.</td>
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<td>• Drink more in hot conditions.</td>
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<tr>
<td>• Replace 80% of fluid loss while still continuing to exercise.</td>
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<th>What to drink</th>
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<tr>
<td>• Water, if exercise lasts less than 1 hour</td>
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<td>• Diluted carbohydrate/electrolyte drink, if exercise lasts longer than 1 hour</td>
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<tr>
<td>• No higher than 8% carbohydrate solution</td>
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<tr>
<td>• Non-carbonated</td>
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<tr>
<td>• Cold fluid, as this empties from stomach faster</td>
</tr>
<tr>
<td>• No alcohol</td>
</tr>
<tr>
<td>• Something that tastes good to encourage drinking</td>
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<th>Following competition</th>
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<tr>
<td>• Use water, then carbohydrate drinks.</td>
</tr>
<tr>
<td>• Replenish fluid regularly until:</td>
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<tr>
<td>– body weight returns to normal</td>
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<tr>
<td>– urine is clear.</td>
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<tr>
<td>• Replace 80% of fluid loss while still continuing to exercise.</td>
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Post-performance
After the event, it is important to:
• replace glycogen stores by eating foods with a high carbohydrate content
• rehydrate to replace fluid lost during the event.

Dietary supplements
The most popular dietary supplements for athletes are vitamins and minerals. While sometimes these are necessary, some athletes believe their intake considerably advantages their performances. Supplementation is not performance enhancing in the same way that drugs such as steroids are. It is an attempt to balance a diet that might otherwise be lacking. If the benefits of supplementation are realised, it will provide a platform for optimal performance rather than enhance performance through chemical means. See chapter 9, pages 234–9 for additional details.

Case studies of elite athletes
Examine case studies of elite athletes in relation to:
• how they train
• pre, during and post-performance diet and hydration
• psychological preparation for competition.
Outline the relevant features of each area and discuss how they affect performance. For guidance on locating athletes’ profiles, visit the website for this book and click on the Australian Sports Commission and QuikDoc weblinks for this chapter (see ‘Weblinks’, pages x–xi).

Environmental considerations
Environmental factors such as changes in altitude affect performance. This might involve training at a low altitude and then needing to compete at a higher altitude or perhaps training at a high altitude in the hope of an improved performance at the lower altitude. Although considerable knowledge has been gained in relation to altitude training and acclimatisation in recent decades, more work still needs to be done, particularly in relation to the perceived benefits of altitude training.

Altitude
Altitude affects physical performances in which the aerobic energy system is the dominant system for supply of energy for that event. The higher the altitude, the more significant the physiological effects. The importance of altitude was highlighted at the Mexico City Olympic Games in 1968, where no world records were broken in distance events that lasted longer than 2.5 minutes. Mexico City, at 2290 metres above sea level, proved difficult for endurance athletes, stimulating further research into altitude training.

As altitude increases, barometric pressure decreases (see figure 14.20). This means that air density decreases the further one rises above sea level. While the percentage of gases in the air remains the same (oxygen 20.93 per cent, carbon dioxide 0.03 per cent and nitrogen 79.4 per cent) irrespective of whether one is at sea level or a high altitude, the partial pressure of oxygen progressively decreases with ascendancy. In fact, at 5000 metres above sea level, a continued existence using normal breathing mechanisms is impossible.
Hypoxia is a deficiency of oxygen. Decreased partial pressure means that less oxygen is available to the tissues, resulting in hypoxia. As hypoxia develops, cardiac output is increased at sub-maximal workloads, but decreased during maximal work. With the blood unable to sufficiently load with oxygen, metabolism of glycogen is decelerated, leading to lack of energy in middle- and long-distance events. Aerobic capacity is reduced by 3 per cent for every 300 metres ascended above 1500 metres. This means that the aerobic capacity of athletes performing at Mexico City would have been reduced by about 10 per cent, explaining their inability to break existing world records in events that depended on aerobic metabolism. Respiration rates also increase because there is less oxygen available in the inspired air. Subsequently, the breathing rate increases in an endeavour to provide more oxygen to the lungs. The effect of high altitude on aerobic capacity is illustrated in figure 14.21.

**Figure 14.20:** As altitude increases, barometric pressure decreases making the ability to perform increasingly difficult.

**Figure 14.21:** Aerobic capacity is progressively reduced as altitude increases. (Source: Adapted from W McArdle et al., *Exercise Physiology*, Lippincott, Williams & Wilkins, Baltimore, 1996, p. 486.)
Increased altitude also affects air temperature and solar radiation. Both these factors can affect performance. However, the effects are much more evident in endurance events. The reverse is true for sprint events where ‘thin’ air provides less resistance to the body. Air temperature decreases by one degree Celsius for each 150 metres ascended.

In addition, humidity is lower at high altitude environments than at sea level because cold air is unable to hold the same quantity of water as warm air. This contributes to dehydration. Low humidity also affects ultraviolet radiation, as there is less moisture to absorb the sun’s rays. Athletes performing at altitude need to be aware of this and take additional sun protection precautions.

**Acclimatisation**

Adjustment to altitude results in people’s gradual adaptation to hypoxic conditions. It is a three-phase process and takes two to three weeks for the biological effects to maximise.

- **Phase 1.** The first response is the increase in lung ventilation made necessary by the demand for more oxygen. Athletes consciously breathe deeply and fully in search of additional air.

- **Phase 2.** The lower partial pressure of oxygen results in **erythropoietin** production, which causes growth in red blood cell numbers and a subsequent increase in haemoglobin. This increases the oxygen-carrying capacity of the blood (see figure 7.19, page 201).

- **Phase 3.** There is increased capillarisation of muscle cells and an elevated concentration of oxidative enzymes in the blood.

For some time it was felt that altitude training would be of considerable benefit to athletes, who could then return to sea level with the advantage of having greater oxygen-carrying capacity. Most research suggests that much of the benefit is lost in the first few days following return to sea level. However, this area is still the subject of considerable debate. The biggest difficulty with altitude preparation is that both the volume and intensity of training must be reduced because less oxygen is available to tissues. This problem is accentuated as height increases. At very high altitudes, any advantage is eroded by the reduced training volume enforced by the environment. This having been realised, most altitude training is now conducted at between 1500 and 2000 metres, where the volume is not significantly affected and some gains might be apparent.

Awareness of acclimatisation is more significant for athletes who have trained at low altitudes and who will then compete at high altitudes. The effects of high altitudes become apparent within 24 hours of experiencing the new conditions. Athletes must then take two to three weeks for the body to make adaptations to the new environmental conditions.

**Psychological preparation**

For elite performers, physical preparation is only part of the training program. According to sport psychologists, a big difference can be made to athletes’ performance by changing the way they think about their performance.

**The role and use of sport psychologists**

Psychology has been used in the field of learning for decades. Educators have understood the importance of intangible factors such as confidence and personality in learning skills and in changing behaviours for some time. However, with the growth of sport into big business, many competitors have
realised that a mix of physical and psychological preparation is critical for success.

The use of sport psychology is intended to prepare the athlete’s mind for competition in the same way as the body. The focus is on psychological training to establish mental toughness. It works in the broad areas of:

- motivation
- stress management
- imagery
- arousal
- concentration
- positive self-talk
- goal setting.

The use of sport psychology does not imply that there is something inherently wrong with a player. Rather, it is an opportunity to maximise player potential by ensuring that mind and body are working in harmony and to appreciable advantage. The sport psychologist aims to:

- help athletes overcome the pressures of competition. These pressures might come from coaches, parents or perhaps their own expectations. The sport psychologist tries to increase the athlete’s skill in using a range of techniques that provide emotional control before and during performance.
- improve performance by teaching techniques and strategies for mental control and alertness
- provide psychological assistance during times of poor mental wellbeing, such as those caused by injury or failure to be selected in the team
- educate coaches and players about how to increase enjoyment, satisfaction and harmony within themselves. For instance, the sport psychologist might conduct sessions on team-building, personal development, communication or relaxation techniques.

Relaxation techniques

High levels of anxiety can prove detrimental to sports performance. Worrying about making a false start, being apprehensive about letting the team down or fearing missing the ball, if using a bat or club, can cause nervous tension to rise. Athletes commonly use a number of techniques to relax the mind and body. However, the right technique for one person may not work as well for another. The following list contains a selection of relaxation methods.

- Progressive muscular relaxation. The individual tightens or contracts a muscle group for a period of five seconds and then relaxes. The sequence is continued for all major muscle groups throughout the body.
- Mental relaxation. The focus here is on generating relaxing thoughts by visualising tranquil experiences. The feeling of relaxation then flows through to the muscles.
- Mental rehearsal. This requires the athlete to repeat a mental picture of the required performance. With thoughts narrowed to the task and only successful performances accommodated, confidence increases and the muscles gradually relax.

Figure 14.22: Massage can provide mental relaxation and can help to relieve muscle tension and soreness.
• **Centred breathing.** This popular technique requires the athlete to focus on breathing depth and rate in preparation for the next movement. Hands are usually placed on the waist and slow, deep breaths taken. Air is expelled slowly as the mind and muscles try to relax. It is particularly important to let the large abdominal section control breathing rather than the chest and rib cage. This takes practice and concentration, but is highly productive in triggering muscular relaxation.

• **Flotation.** This technique may be used generally or well in advance of the performance. Aided by a buoyancy vest, the athlete floats in water and the sensations induce feelings of calm.

• **Meditation.** This technique requires the exclusion of interference that might come from the surrounding environment. With a focused mind, a key thought or word is repeated time and time again. As awareness of the surroundings decreases, the mind relaxes, causing muscles to lose tension.

• **Sports massage.** This technique may be used before or after performance. Here, the soft tissue is manipulated by a therapist using one of a range of actions such as vibrating, gliding, stroking or stretching. Stroking or gliding is best for producing a relaxation response. Where stroking is used, the movement is towards the heart wherever possible.

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**COACHING CONSIDERATIONS**

**critical question**

What are the coaching considerations for improving performance?

**Establishing training programs**

Training programs need to be thoroughly planned if the potential of players and the performance of teams are to be optimised. Short-term training sessions need to be linked to long-term training plans that measure improvement against established goals. The types of activities, volume of work and intensity of effort are related specifically to phases of competition.

**Phases of competition and long-term plans**

The phases of competition involve pre-season preparation, a competition period and an off-season or transition phase at the end. During this time, a coach must plan to develop:

- physical stamina or condition
- physical attributes such as strength and flexibility
- skills such as running and batting
- tactics that will provide an advantage during competition
- mental training that will consolidate and improve physical performance.

For elite performers, some training plans will cover a period of years. However, the yearly or annual plan is the most used because most competitions are organised on a seasonal basis. The aim of the annual plan is to ensure there is an appropriate balance between work and recovery and that peaking occurs at the right time. It is usual to divide the annual plan into smaller training periods called macrocycles and microcycles.

The importance of planning by using macrocycles and microcycles is illustrated in figure 14.23. It allows coaches to plan and monitor all aspects of the training program and ensure that periods of high intensity are followed by periods of unloading. This is referred to as periodisation. Use of macrocycles allows tracking of training volume and intensity. These will fluctuate and...
decrease, reflecting changes in the work–recovery ratio. The microcycles allow focus on the specifics of individual training sessions, of which there might be many in a typical week. Sessions will be characterised by varying volumes and appropriate recovery periods.

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<td>Pre-season</td>
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<td>Basic conditioning</td>
<td>Specific conditioning</td>
<td>Unloading</td>
<td>Unloading</td>
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<td>Peaking</td>
<td>Transition</td>
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<td>SPEED</td>
<td>Develop running speed</td>
<td>Develop movement speed</td>
<td>Maintain</td>
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<td>ENDURANCE</td>
<td>Develop aerobic capacity</td>
<td>Maintain aerobic capacity</td>
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<td>FLEXIBILITY</td>
<td>Develop</td>
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<td>SKILL</td>
<td>Improve specific skills</td>
<td>Develop skills under pressure</td>
<td>Improve basic skills</td>
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<td>TACTICS</td>
<td>Implement</td>
<td>Consolidate</td>
<td>Devise and test</td>
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<td>PSYCHOLOGY</td>
<td>Goal setting</td>
<td>Simulate competition strategies</td>
<td>Increase motivation</td>
<td>Goal setting</td>
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<td>Volume</td>
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<td>Intensity</td>
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**Figure 14.23:** The chart of an annual plan (Source: Adapted from T Bompa, Theory and Methodology of Training, 3rd edn, 1994, Kendall Hunt, Dubuque, Iowa, p. 211.)

**Optimising the performance of athletes**

All plans need to ensure that peaking occurs at the intended time. This is the case for both individuals and teams. To ensure this occurs and is appropriately timed, it is important that training loads and recovery periods are individualised, even though team preparation is the overall objective. Staleness suffered by some players during the early parts of the competitive season can negatively affect performance.

**Data gathering and analysis of training and performance**

Effective programs are developed based on data gained from previous seasons and current performances. Data are gathered in the form of:
- personal and team goals
- tests and standards, including speed, strength, flexibility, and coordination
• statistical information
• psychological needs, including motivation and arousal control
• performance needs, in terms of skill and technique
• equipment needs
• positive and constructive interaction between squad members.

Information from these and other sources (assistant coaches, trainers, managers and sport psychologists) is gathered, assessed and used to formulate the annual plan. Data collection and analysis of training is important, as it provides a benchmark against which performance is measured.

**Developing an annual plan**

Using figure 14.23, construct an annual plan for a sport of your choice. Ensure that it is tailored to the specifics of the sport and that it will allow peaking to occur at the right time. Display your plans around the classroom and comment on any unique features.

**Elements of a training session**

The elements of a training session incorporate many of the practices we are familiar with as players, including warm-up, warm-down, conditioning, drills, and the practice of moves and strategies.

**Providing an overview of the session to athletes**

At the beginning of a training session and particularly where teams are involved, it is common for coaches to provide a brief overview of what will be expected during the session. This ensures that the intentions of the coach and expectations of players are channelled in the same direction. It also has the advantage of gathering the players in a forum situation, where specific issues can be addressed. Some of these may include:

• recording of player presence or absence
• assessment of injuries
• discussion of previous performance
• special tactics suggestions that might need to be considered.

**Warm-up**

An effective warm-up will consist of the following phases:

• **Phase 1:** general body warm-up until the body begins to sweat. Some suggested activities are jogging and skipping.
• **Phase 2:** stretching. This is important in ensuring that the required muscle groups are extended beyond the range that will be required of them in the sport itself. In addition, stretching promotes blood circulation, increases muscle relaxation and improves performance. Stretching exercises need to be safe. Sports Medicine Australia has issued a brochure that contains an extensive range of warm-up exercises, some of which are illustrated in figure 14.24.
• **Phase 3:** callisthenics. These are general body exercises, such as push-ups and abdominal crunches, that involve large muscle groups (see figure 14.25). These exercises should be specific to the game; that is, they should work the muscle groups that will be involved in the game or activity itself. For this reason, the exercises should not be exhausting.
Neck flexion/extension stretch — move head forward then back.

Lateral flexion stretch — one side then the other; push pelvis across as you bend.

Supraspinatus stretch — keep elbow parallel to the ground.

Thoracic extension stretch — reach forward with arms, push chest towards floor, arch back down, bottom behind knees.

Hip flexor stretch — keep back straight, tuck bottom under, lunge forward on front leg.

Gastrocnemius stretch — keep your knee straight and heel on ground, and face feet forward.

Shoulder rotator stretch — use towel, pull it up with upper arm and then down with lower one.

Hamstring stretch — start with knee bent a little, then push knee straight as tension allows, and push chest towards foot.

Quadriiceps stretch — keep pelvis on floor.

Figure 14.24: Some general stretching exercises appropriate for warm-ups
(Source: Adapted from Sports Medicine Australia.)

Figure 14.25: Calisthenics such as (a) push-ups and (b) abdominal crunches help strengthen muscle and prepare it for use.
Phase 4: Skill rehearsal. In this phase, the athlete will perform some routines required later in the game. Team game players such as soccer players and basketballers will participate in patterns (for example, dribbling in basketball) that will increase agility and replicate movements required in the game. There will be an emphasis on maintaining the body temperature that was established through previous physical work.

Skill instruction
Instruction at a training session refers to delivery of a body of knowledge by a coach (or coaches and trainers) to the players. Good instruction requires prior organisation and effective communication skills. All coaching sessions need to be well planned, need to provide guidance on how to perform the fundamental skills, and should allow these to be practised in related drills and movements. There should also be instruction on the other related aspects of the session including warm-up and warm-down, stretching and flexibility, strategies and tactics, game plans and, finally, procedural details such as the time and venue for the next game. Effective instruction will be:

- **brief** — it is important that instruction is concise and factual to allow maximal practice time
- **well timed** — use words when their impact will be greatest
- **specific** — instruction needs to be specific to the skill, game and situation; it should not be general
- **constructive** — focus on the positive points for improvement, not on how poorly the skill is being performed.
- **clear** — there should be no misunderstanding about the information communicated by the coach. Questions should be encouraged if the message is not understood.
- **informative** — all instruction should relate specifically to information that the players need to know. Additional, unrelated material is confusing and can actually hinder the learning process.
- **demonstrable** — effective instruction is supported by visual aids such as demonstrations to provide clear pictures of skills and techniques.

Skills practice
Skills practices are the backbone of the training session. Once players are warmed up and conditioned, coaches need to spend the majority of the remaining time on skills practices. These need to specifically target:

- improvement in the fundamentals of the game
- individual needs in specific areas — for example, ball handling
- performance under gradually increasing pressure
- provision of enjoyment through competitive situations
- an increase in knowledge of the game
- development of cognitive or thinking abilities
- development of communication via skills practices.

Many skills are difficult for young players to learn and will need to be broken down into subroutines. For example, the subroutines in the lay-up in basketball for a right-handed player consist of catching the ball in the
Temporal patterning refers to the ability to execute the subroutines in correct sequence.

The cool-down is the period of time following physical activity where the body temperature, circulation and respiratory rates are returned to their pre-exercise state (or as close to this state as possible).

air, landing on the right foot, stepping onto the left foot, driving towards the basket, releasing the ball and landing. This is called the part method of teaching. However, as the movement is learned, the skill can be incorporated into a skills practice situation such as continuous lay-ups from one side of the court. As temporal patterning develops, the challenging nature of skills practices can be increased by adding to the range of skills that needs to be mastered to complete a movement.

Conditioning
Fitness training is an integral part of every training session. Most sports have a short fitness session immediately following the warm-up. Supplementary fitness in the form of circuits, interval training, continuous training and calisthenics usually takes place following a session of individual and team play. Work on fitness should not be overemphasised in the first session, as this will fatigue players and adversely affect concentration and performance in the skills and team play session. It is essential that during the fitness session heart rate reaches training zone intensity (70 to 85 per cent maximal heart rate) and remains there for at least 20 minutes.

While the fitness session needs to be thorough and challenging, it does not need to be totally exhausting, which would lead to an excessive build-up of lactic acid. Effective coaches are able to continue to address fitness needs through skills practices. Most drills requiring agility, speed, endurance, power and coordination help the development of fitness components. Coaches need to be aware of the element of fatigue in skill learning. While fitness can be addressed in some skill-learning situations, it is important not to fatigue players unduly, as concentration and interest will suffer. It is particularly important to make regular testing part of the fitness program in order to provide feedback and to be a source of motivation.

Cool-down
The practical part of a training session is concluded with a cool-down. The procedure here is virtually the reverse of the warm-up. However, it is not as intense and need not extend for the same period of time.

Evaluation
Evaluation is an appraisal of performances after the training session. It is normally carried out during and after the cool-down and involves coaches and players reporting on the value of the session. An evaluation should address performance outcomes; that is, it should address the performance goals for the session (for example, learning the serve in tennis) and how well the goals were achieved. Evaluation also needs to address behavioural outcomes such as punctuality. Players should be given the chance to express opinions on issues that may have arisen from the training session.

Evaluation of the coaching session is followed by a brief reminder of the date, time and venue of the next fixture and training session and a recheck of player availability. Individuals with specific problems, such as taping requirements, should see the coach and make special arrangements. It is important that training sessions finish at the arranged time.

The final step, following the session, is an evaluation by the coach as a preparation for future sessions. This could include an analysis of the fitness testing and skills testing results and a review of the game performance. The time allocation to the various elements of a training session is illustrated in figure 14.27.
Designing a training session

Design a training session for a sport of your choice. Include time allocation for the different elements plus warm-up and cool-down activities, skills practices, strategies, and information relating to other training session elements. Compare your session with others in your class. Choose one of the training session plans, conduct it with the class and then evaluate.

Health and safety considerations

Health and safety is as important in training as in game situations. Coaches and athletes should be aware of the guidelines, which are outlined in chapter 13, page 409.

Overtraining

Sometimes, because of poor scheduling or high levels of dedication, an athlete can suffer chronic training stress, which leads to performance deterioration. In the early stages, it might be recognised as staleness. However, staleness can progress to two, more chronic conditions known as overtraining and ultimately burnout.

Amount and intensity of training

Overtraining develops as a result of subjecting athletes to high-intensity training practices when they are in a stage of fatigue. High-intensity training requires a longer period for regeneration and refreshment than does moderate training. A coach must be careful to balance work requirements with an appropriate recovery period. When there is too much work and insufficient time for recovery, the athlete becomes physically fatigued and mentally drained in what is called the overtraining state.

The onset of the overtraining state can be recognised by lack of motivation and poorer performances. However, its steady development is concealed and difficult to establish objectively. While the best signs are an increasing resting heart rate and higher blood lactate levels, the observation of performance, amount of drive and level of enthusiasm is the most effective detection method.
Physiological considerations
The underlying cause of overtraining is a combination of physiological and psychological factors. While the poorer performance is obvious, the exact causes might be more difficult to identify. However, they include a range of training practices and general stressors including:
- environmental stress
- sleep disorders
- poor nutrition
- excessive training volume
- excessive training intensity.

The effect of these could be identified by the athlete’s exhibiting characteristic overtraining symptoms, including:
- insomnia
- decreased appetite
- loss of muscle strength and coordination
- muscle soreness and fatigue
- elevated resting heart rate
- colds and possible allergic reactions
- increased susceptibility to infections.

Psychological considerations
Psychological factors are also important. Some stressors that might contribute to overtraining include:
- pressure to perform
- psyching up too frequently
- boredom
- fear
- lack of self-confidence
- anxiety
- lack of encouragement.

Most of these stressors are low key and are usually handled appropriately during normal training. However, when physical stability is threatened, emotional factors assume greater magnitude and affect health and wellbeing. The result is a loss of motivation, enthusiasm for training and competitive desire. Symptoms might include:
- increased nervousness
- poor concentration span
- irritability or anger
- emotional sensitivity
- depression.

Athletes suffering overtraining require one strategy or a number of strategies, including:
- the reduction or cessation of training
- active rest
- change of environment
- change of routine
- mini breaks
- a reduction in pressure.

Prevention of the overtraining state is best achieved through being careful not to exceed an athlete’s stress tolerance, and adapting the volume and intensity of training to each individual.
The use of technology

The use of technology to gain an advantage in sport has gained considerable attention in recent decades, particularly since the first moon landing in 1969. This feat was dependent on extensive development and use of computer technology and on the construction of strong but lightweight attire and equipment. The benefits of immense technological advancement were soon realised by the rest of the world, and entrepreneurs in both business and sport adapted the technology for refinement in their own areas. Improved cycling helmets, graphite golf shafts, lycra bodysuits and sharkskin swimsuits are only some of the improvements made possible by substantial technological progress in the last half century. It would be difficult to discern which advances were more significant in terms of performances or more beneficial to sport itself. Certainly the use of computer timing, in sports such as swimming, and video analysis to improve performance rank among the most important developments.

Training innovation

Innovations that have assisted training and competition performances in recent years are extensive. Some of the more recent innovations are listed in table 14.6.

<table>
<thead>
<tr>
<th>Sport</th>
<th>Innovation</th>
<th>Implications</th>
</tr>
</thead>
<tbody>
<tr>
<td>High jump</td>
<td>High jump mats used instead of sand Techniques like the Fosbury flop instead of the scissors</td>
<td>Heights cleared by athletes are increased because landing on their back is now possible.</td>
</tr>
<tr>
<td>Pole vault</td>
<td>Carbon fibre poles</td>
<td>Material allows greater flex and therefore increased vertical propulsion over the bar.</td>
</tr>
<tr>
<td>Running</td>
<td>Lightweight nylon used in spikes Lycra clothing</td>
<td>Weight and air resistance effects on times are reduced, and comfort for the athlete is increased.</td>
</tr>
<tr>
<td>Swimming</td>
<td>Lycra bodysuits Caps Goggles Breast stroke whip kick Underwater dolphin movement in backstroke and butterfly</td>
<td>Drag component is reduced. The bodysuits also help flotation. Swimmer achieves greater propulsion through water. Swimmer produces more efficient and powerful force.</td>
</tr>
<tr>
<td>Golf</td>
<td>Synthetic fibres (for example, tungsten used in golf balls)</td>
<td>Balls respond better for distance, spin and control. Durability is improved. Dimples vary to give balls different characteristics (for example, distance or spin). More variation in ‘flex’ creates a higher ‘whipping’ action for extra distance. Greater area of contact results in high level of result (that is, less margin for error). Accuracy is increased. Lighter material allows more mass at the point of contact, creating greater distance.</td>
</tr>
<tr>
<td>Cycling</td>
<td>Carbon fibre components</td>
<td>Frames, pedals, wheels, gears, etc. weigh less, so create less resistance. The efficiency of the cyclist’s effort is increased. The shapes and designs of components are more aerodynamically sound. Cyclists can ride more extreme country safely. The stress on cyclists’ bodies is reduced, so energy can be focused on creating forward motion.</td>
</tr>
<tr>
<td>Sprint running</td>
<td>Crouch start versus standing start</td>
<td>Biomechanical efficiency is increased and quadriceps are able to create greater forward force out of the blocks.</td>
</tr>
</tbody>
</table>

(continued)
Table 14.6: (continued)

<table>
<thead>
<tr>
<th>Sport</th>
<th>Innovation</th>
<th>Implications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discus/shot put</td>
<td>Rotation (spin) delivery</td>
<td>Velocity of projectile is increased at point of release. Momentum is increased as a result of the combined muscle actions involved.</td>
</tr>
<tr>
<td>Athletics</td>
<td>Rubber compound used in tracks and runways</td>
<td>Tracks respond to effort, so the efficiency of an athlete’s output is increased. There is a high reaction component for jumps and forward motion.</td>
</tr>
<tr>
<td>Australian football</td>
<td>Configuration of stops used in football boots</td>
<td>There is less stress on players' feet because boots are like running shoes; agility is increased.</td>
</tr>
</tbody>
</table>

**The fabric**
Based on the skin of the shark the super-stretch (higher elastane content) fabric reduces muscle vibration, decreasing fatigue and power loss.

**Ridges**
V-shaped ridges work like tiny spoilers, decreasing drag and turbulence around body surface.

**Denticle print**
Imprint flowing in the opposite direction to the ridges, which suck the water closer to the body, reducing friction drag.

**Body Map/panels**
A 3-D map of the elite swimmer’s body, identifying movement and stretching patterns, as well as reflecting the muscular system.

**Gripper**
Swimmers feel the water with the inner forearm. A higher degree of drag enhances the sensory feeling of this part of the body.

**Seams**
Highly elastic – enabling a full range of movements while acting like tendons, providing tension between the suit panels. Follow the flow of water – minimising drag.

**Figure 14.28**: The Fastskin suit — a training innovation (Source: From an article by Jacquelin Magnay in *The Sydney Morning Herald*, 14 April 2000.)

**Video analysis of performance**
Video analysis is now used in a range of coaching, viewing and performance appraisal situations. Video allows analysis of player movements, strategies and techniques, with a view to:

- **Improving technique.** The way a player executes a movement such as a tennis serve or swimming stroke can be observed repeatedly in slow motion to locate error.
- **Improving visualisation.** By observing a skill performed repeatedly or in slow motion, a player’s conceptualisation of what is required for proper execution is enhanced.
- **Establishing biomechanical efficiency.** By observing the movements of skilful players, coaches can gain an insight into how movements can be performed more efficiently and demonstrate these to their players.
- **Analysing strategies.** Coaches (particularly in team sports where there are numerous movements occurring with the ball and away from the ball) find video replays useful for analysing the effectiveness of strategies used both by their team and their opponents.
Data gathering and analysis

The increased professionalism of sport has made gathering and analysis of data important in understanding performance and using it for improvement. Data is gathered using:

- video analysis
- statistics
- results and records
- personal notations.

Because of the quantity of information gathered and the need for it to be analysed and ready to use, modern coaches often use computer programs for storage and retrieval. The data may be used by tacticians, statisticians, coaches and athletes to improve both team and individual performances.

CASE STUDY

Analysing our game plan

By David Parkin

For a long time now football [AFL] coaches have been collecting data about their team’s performance. Since the 1960s statistics have been collected. We started with kicks, marks and handballs. These were manually taken by the club’s statisticians during the game and reviewed post-match by the coaching staff.

There have been massive developments in this area of game analysis in the past four decades. We now have teams of people with the latest computer and video technology to gather appropriate information relating to ours and the opposition’s game plan and game performance. Not only can we evaluate the performance following the game, we can record and have available important data in real time (during the game).

Coaches and their analysts can now give meaning to the current game, then, via the runner and breaks between quarters, provide specific direction to players. This can reinforce the inputs, tactics and strategies which are obviously working but, at the same time, indicate where improvement is needed to lift an individual’s or team’s performance . . .

For the football student and enthusiast, we now have a couple of professional IT companies (Champion Data and Prowess Sports) who are gathering this information on behalf of all clubs. Their data, being used by all forms of the media, plus what clubs collect for themselves, are finally giving us the capacity to understand, analyse and benchmark the game plans. What a bonus to have a set of key performance indicators which accurately underpin our game plan. If we know there is a strong relationship between the levels of certain player/team inputs and our ability to play well, and even win, then we have a clear advantage over any club who can’t complete the same process . . .


Inquiry

Technology and sport

Using the text and your own research and experience, create a PowerPoint presentation on ways in which technology has changed the role of the coach in improving the performance of athletes.
Effective strength training requires exercise design for specific muscle groups. By manipulating variables such as resistance, sets, speed, repetitions and rest, strength training can address different needs.

There are three types of resistance training: isotonic, isometric and isokinetic. Isotonic, or use of free weights, is the most widely used.

Advanced weight training sometimes employs highly specialised overload techniques such as forced repetitions and pyramid sets, which provide added strength.

Training for power and speed requires resistance training programs to ensure that exercise speed is increased. Plyometrics, or bounding activities, are excellent for developing power.

Resistance training for endurance events needs to be specialised to cater for the particular type of endurance required. Generally speaking, the greater the endurance required, the lower the resistance should be and the greater the number of repetitions.

The two broad types of flexibility training are dynamic and static. Static flexibility is an indication of the range of movement at a series of joints while the body is in a fixed position. Dynamic flexibility is the ability of the muscles to move a joint through its full range of motion. ROM and ballistic stretching both improve dynamic flexibility.

While increased flexibility is important, particularly for the prevention of injury, the types of movement performed need to be safe. Unsafe movements are called contraindicated movements.

Skill and movement finesse can be improved by a range of methods including drills, video analysis and correction techniques used by the coach.

Training for competition has three phases: pre-season, competition and post-season. Peaking is the period at the height of the competition phase and this is followed by a period of tapering.

All competitive athletes need to be aware of dietary considerations and fluid replacement principles. Females have special needs in relation to iron and calcium.

Elite athletes may compete in a range of climates and at varying altitudes. High altitudes affect endurance performance. Altitude training may marginally improve aerobic performance, but this area is still the subject of debate.

Many elite athletes now use sport psychologists to ensure that the benefits of physical training are not eroded by negative thought patterns.

Effective coaching requires the establishment of annual plans linked to the phases of competition. These are subdivided into smaller units called macrocycles and microcycles. The use of small cycles allows better management of training volume and intensity.

All training sessions have a number of elements, including warm-up, conditioning, skills practice, evaluation and cool-down.

Coaches and players need to be aware of blending appropriate volume and intensity with sufficient periods of unloading. Too much work with insufficient recovery times leads to overtraining.

Use of technology has flourished in sport in recent years. It ranges from equipment and timing mechanisms to video analysis and computer data processing.
Revised

1. Using exercises as examples, outline the difference between isometric, isotonic and isokinetic training programs. Suggest the advantages of each in building strength. (H8)

2. Explain the value of using overload techniques to supplement strength training programs. (H7)

3. Outline the elements of an exercise prescription for power. Suggest how this would differ from a prescription designed to improve absolute strength. (H7)

4. What is plyometric training? Suggest a range of exercises that could be used as part of a power development program. (H10)

5. Outline the effects of training on the aerobic system. Detail a method relating to how improvements in aerobic capacity could be measured. (H7, H16)

6. Outline the benefits of PNF stretching. (H10)

7. What are contraindicated movements? Outline the criteria on which movements are judged safe or unsafe. (H17)

8. Examine the back arch and toe touch as illustrated on page 451. Explain why the movements are contraindicated and suggest an alternative safe flexibility exercise for each. (H16)

9. Describe the characteristics of the preparation phase that makes it different from the competition phase of a training program. (H10)

10. What is meant by peaking and tapering in performance? How would you assess if an athlete was at the peak of performance? (H9, H16)

11. ‘Altitude training significantly enhances physical performance.’ Discuss. (H8)

12. Discuss the role of sports psychologists in improving performance. (H11)

13. What are the elements of a training program? Suggest how each element improves movement potential. (H7)

14. What is overtraining and how is it identified? (H16)

15. Discuss how video analysis could be used to improve the way a skill is performed. (H16)

16. Suggest techniques available to a sport psychologist to assist a high jumper who is experiencing negative thought patterns before each jump. (H11)

Extension

1. Investigate an area in which technology has made a significant difference to performance. Outline the changes work to improve performance, and suggest future developments in this area. (H8)

2. Choose a sport or activity. Using the syllabus as a support or scaffold, apply each of the critical questions listed in ‘students learn to...’ sections of the syllabus. (H7–H11, H16, H17)