INQUIRY QUESTION
Evaluate what training methods would be most appropriate to include in a Goal Keeper's training program and how you would apply the important training principles correctly to the training methods selected.

CHAPTER

11 Training program principles and methods

In order for a training program to achieve the goal of enhancing and/or maintaining fitness components, its design requires the correct application of training principles and methods.

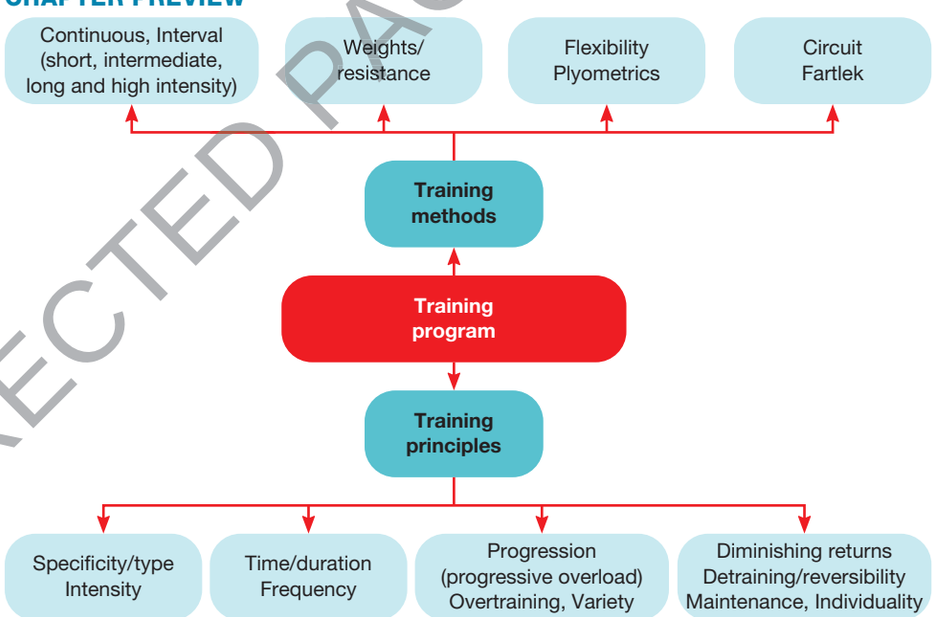
KEY KNOWLEDGE

- Training program principles, including frequency, intensity, time, type, progression, specificity, individuality, diminishing returns, variety, maintenance, overtraining and detraining
- Training methods including continuous, interval (short, intermediate, long and high intensity), fartlek, circuit, weight/resistance, flexibility and plyometrics

KEY SKILLS

- Design a training program that demonstrates the correct application of training principles and methods to enhance and/or maintain fitness components
- Evaluate and critique the effectiveness of different training programs

CHAPTER PREVIEW



11.1 Specificity, intensity and type of training

KEY CONCEPT Specificity, intensity and the type of training are training principles that are vital in achieving the overall goal of improved performance.

Specificity

Specificity is the process of replicating the characteristics of physical activity in training to ensure it benefits performance.

Of all the principles of training, **specificity** is the most important. Whether the aim of the training program is to improve general fitness or to become a better performer in a particular sport, it is essential that all training aspects are relevant to the overall purpose of the program.

The activity analysis provides information about the activity/sport that allows for the principle of specificity to be applied. The important aspects that are identified in an activity analysis are the following:

- the predominant energy systems required
- the fitness components used
- the muscle groups used
- the skills performed
- the fatiguing factors.

It would be pointless for a tennis player who requires agility, short sprints, skills work and resistance training to follow the training schedule of a marathon runner who completes 200 kilometres of continuous training per week. Obviously, the aspects identified above have different applications in the two sports, and the training for one would not be specific to what is needed for successful performance in the other.

FIGURE 11.1 It is essential that Thanasi Kokkinakis trains the specific energy systems, muscle groups and fitness components that are required for him to be competitive in tennis at the highest level.

It is also important to select training methods that are specific to addressing the identified needs for optimum performance levels. If the athlete needs to focus on upper body strength, anaerobic power and the ATP–CP energy system, it would be counterproductive to choose continuous training that is specifically for aerobic improvement and lower body local muscular endurance.

For team sports such as netball, Australian Rules football, rugby and soccer, an activity analysis on each particular position and/or player would reveal quite different physiological characteristics that are required for optimal levels of performance. The energy system and fitness component requirements of a striker in soccer would be very different to those of the goal keeper.

As discussed in chapter 7, the completion of an activity analysis is a critical step when applying the principle of specificity to a training program.

If an activity analysis of an elite tennis player such as Thanasi Kokkinakis revealed that leg power and agility are two important fitness components needed for optimum levels of performance, then the principle of specificity would require the athlete to:

- test these fitness components by using tests such as the vertical jump test and the 5-0-5 Agility Test (refer to chapter 9);
- design a training program that includes circuit training sessions that specifically work on muscular power and agility in the leg muscles

- select exercise stations that work specifically on leg power, such as squat jumps or drop jumps, and agility exercises such as speed and ladders
- ensure that the application of other training principles, such as type, intensity and time, are specific to the needs of the game of tennis.

If the tennis player trains the specific energy systems, fitness components, muscle groups and also accounts for the fatiguing factors relevant to the game of tennis, they will achieve the chronic adaptations that allow them to perform at their optimum fitness in a game situation. However, a very important aspect of the tennis player's game is the execution of a high level of motor skill. It is essential that the tennis player also includes a specific skill component into each training session. Appropriately targeting the physiological requirements of the sport will enhance the likelihood of the athlete performing to the best of their ability. There are other influences such as psychological factors, nutritional intake and hydration status that may also ultimately affect the player's performance and these are discussed in chapter 13.

The **SAID** principle is a well-known acronym in the sports science field and it stands for *Specific Adaptations to Imposed Demands*. This means that the specific training that is undertaken will determine the type/s of physiological adaptations that will occur. For example, weight/resistance training specifically designed for strength improvements will result in an increase in motor unit recruitment, an increase in the rate and speed of neuromuscular firing, an increase in the size and number of myofibrils and an increase in the protein filaments actin and myosin as a result of the imposed demands placed on the muscles. Alternatively, long-interval training will result in an increase in the number of myoglobin stores in the muscles, which will enhance oxygen extraction and delivery to the mitochondria for energy production and improved aerobic efficiency. The chronic adaptations that occur are therefore defined by the specificity of the particular aspects of an athlete's training program.

The **SAID** principle stands for Specific Adaptations to Imposed Demands.

By identifying, through an activity analysis, the sport's requirements and targeting them specifically in a training program, the athlete can be more certain about meeting the overall goals of the training program. The principle of specificity should guide the appropriate application of all other training principles.

FIGURE 11.2 Activity trackers assist the athlete to make their training program specific to the requirements of their sport.

FIGURE 11.3 Adaptations specific to the sport — Cycling.

FIGURE 11.4 Adaptations specific to the sport — Running.

Intensity

Intensity is the exertion level or how hard the training is being performed. It is commonly measured as a percentage of maximum heart rate (MHR), which is determined by beats per minute (bpm).

In terms of fitness gains, **intensity** is the most important training principle. In rudimentary terms the following intensities are a guide to training each energy system:

- ATP–CP energy system — 95–100 per cent of maximum heart rate (MHR)
- anaerobic glycolysis energy system — 85–95 per cent of MHR
- aerobic energy system — 70–85 per cent of MHR.

Therefore, to improve the ATP–CP energy system by doing 50-metre sprints, the athlete needs to perform the sprints at 95–100 per cent intensity (maximum effort).

The intensity at which a person trains will determine the kind of adaptations that will be achieved.

There are a variety of methods/variables used to measure the intensity of exercise:

- percentage of maximum heart rate (% MHR)
- rating of perceived exertion (RPE)
- percentage of VO_2 maximum (% VO_2 max.)
- percentage of **heart rate reserve** (% HRR)
- **metabolic equivalents** (METs)
- blood lactate levels (mM).

The **heart rate reserve** is the difference between resting heart rate and maximum heart rate.

Metabolic equivalents is a system for classifying exercise intensity. 1 MET is equal to resting levels.

Commonly, measurements of intensity are referred to as a percentage of maximum heart rate and/or percentage of VO_2 maximum. Using VO_2 maximum as a tool to measure intensity requires a person to undertake a VO_2 max. test (such as the ones identified in chapter 9) to determine the maximum reference point that percentage exercise intensities can be defined by. However, it is difficult to actually determine oxygen consumption while training and that is why percentage of maximum heart rate is used. Heart rate and oxygen consumption increase linearly with exercise intensity increases and therefore % MHR as a measurement of intensity is justified.

A simple and general calculation for determining Maximum Heart Rate is:

220 – Age = Maximum Heart Rate

A commonly recognised way to categorise the adaptations that occur at different intensities is the division of **training zones**.

A **training zone** describes the intensity range that is required for specific adaptations to occur.

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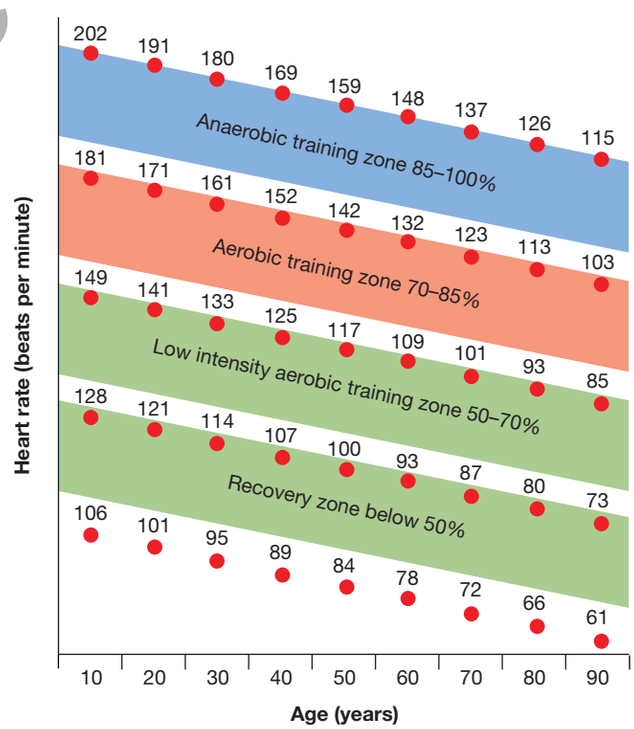

FIGURE 11.5 The various generic training zones according to age and heart rate.

TABLE 11.1 The relationship between other variables and exercise intensity

Training zone	% MHR	% VO_2 max.	RPE	% HRR	Blood lactate (mM)
T6	NA	NA	Maximal	NA	NA
T5	>92%	>86%	Very hard	>86%	> 6.0
T4	90–92%	83–86%	Hard	83–86%	4.0–6.0
T3	85–90%	75–83%	Somewhat hard	75–83%	3.0–4.0
T2	70–85%	60–75%	Light	58–75%	2.0–3.0
T1	60–70%	36–60%	Very light	30–58%	<2.0

= Anaerobic training zone = Aerobic training zone = Low intensity aerobic zone/recovery zone

Source: Adapted from https://www.visualcoaching.com/

METs categorise exercise intensities as:

Light	Moderate	Vigorous
<3.0 METs	3.0–6.0 METs	>6.0 METs

The limitation of using METs as a measure of exercise intensity is that they do not take into account individual fitness levels.

In general terms, a person's **lactate inflection point** (LIP) is thought to occur at an intensity of approximately 85% MHR.

Lactate inflection point is the highest intensity point where there is a balance between lactate accumulation and removal from the blood. It represents a person's highest steady state intensity.

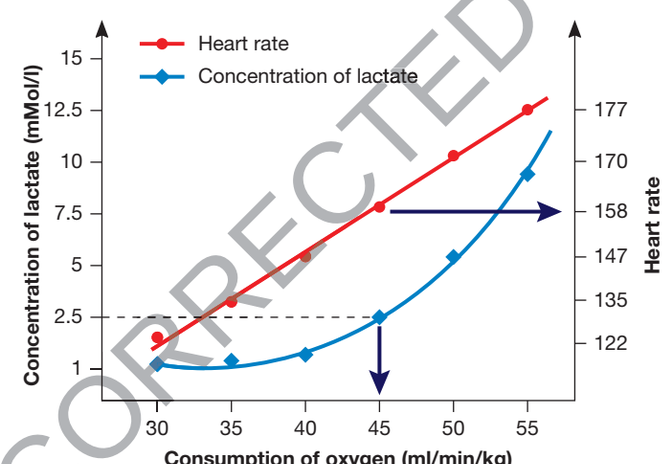

FIGURE 11.6 This graph represents the relationship between lactate concentration, heart rate and oxygen consumption for a successive, bicycle ergometer test, with the exercise intensity starting at about 50–60% of VO_2 max.

Source: http://www.tarleton.edu/Faculty/jblevins/Physiotherapy/Spring%2014/VO2max%20test%20lab%20-%20physiotherapy.pdf

It was determined that the athlete above had a maximal heart rate of 182 bpm, and a relative VO_2 max. of 61 ml/min/kg using a bicycle ergometer test.

Blood lactate concentration will accumulate faster than it can be removed when the athlete's VO_2 max. was 45 ml/min/kg, therefore their LIP occurs at about 74% of VO_2 max.

The heart rate at this point is 158 bpm; therefore their LIP occurs at about 85% of their MHR.

The intensity of a resistance training program will be determined by the load according to a percentage of **Repetition Maximum** (%RM).

The **Repetition Maximum** is the maximum amount of weight that a person can lift in one muscular contraction.

FIGURE 11.7 Michael Shelley, Australian Olympic marathon competitor, Rio 2016

Working at the correct intensity levels is critical to achieving the goals of a training program.

Type

The type of exercises, activities and/or training methods that are included into a training program will also determine the particular adaptations and performance gains achieved. It is important that the type of exercises, activities and/or methods selected are appropriate for achieving the overall training program goals. They should replicate the movement patterns, muscle groups/actions, energy systems and fitness components relevant for the particular sport or activity for which the person is training.

A marathon runner's training program would be predominantly running-based training, whereas a triathlete's training program would require a combination and balance of swimming, running and cycling. Both athletes would, however, need to select training methods that aim to improve their aerobic capacity.

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Unit 4	**Time and type**
AOS 2	Summary screen
Topic 2	and practice
Concept 2	questions

FIGURE 11.8 Aaron Royle leads the men's cycle leg of the World Triathlon

TEST your understanding

1. Define specificity.
2. Outline the important aspects of an activity analysis that specificity must address.
3. What is the most common way to determine training intensity?
4. Identify another way to determine training intensity.
5. State the recommended heart rate training zone for aerobic training.
6. State the recommended heart rate training zone for recovery.

APPLY your understanding

7. Discuss why it is easier to use MHR as the means of assessing training intensity, rather than using maximum oxygen uptake.
8. Determine your aerobic training heart rate zone. Identify your parents' aerobic training heart rate zone.
9. Describe how you would correctly apply the *specificity* training principle to a training program of your choice.
10. Explain how you would correctly apply the principle of *type* to a training program of your choice.
11. Compare and contrast how you would apply the training principle of specificity to a training program for a 50-km road cyclist and an Olympic triathlete who complete the following distances: swim —1500 m, ride —40 km and run — 10 km.
12. **Practical activity**
    Design a training session for a particular sport or activity of your choice that includes the correct application of the principles of specificity, intensity and type. Coach your classmates through the training session. You will need to consider the tool your classmates are going to use to monitor their intensity level.

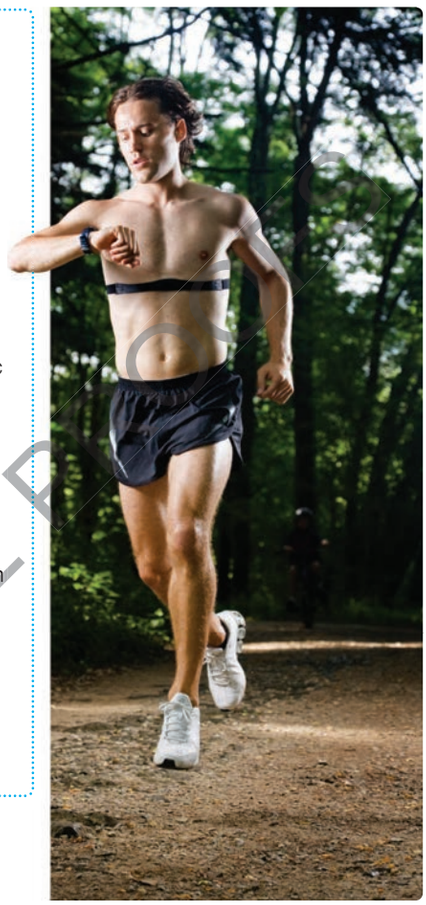

FIGURE 11.9 Heart rate monitors are a reasonably cheap, accurate and increasingly popular method of monitoring exercise intensity.

11.2 Time/duration and frequency

KEY CONCEPT The correct application of the principles of time/duration and frequency is required in order for a person to achieve specific training adaptations.

Time/duration

Time/duration can refer to the length of a training session, the length of a work interval within a training session and/or the length of the overall training program.

The **time/duration** principle is important to consider in combination with the principle of intensity. An athlete will not make fitness gains unless they are working at the required intensity for the required amount of time.

This is important for continuous aerobic training, for example, where improvement requires a minimum session of 20 minutes with the person operating at 70–85 per cent of their maximum heart rate. It is equally important if the desired outcome is improvement in the ATP–CP system. The work intervals within the training session should be short (approximately 10 seconds) and at maximum intensity.

The principle of time/duration also refers to the minimum length of time for a training program to result in improved fitness. This is dependent on the type of training methods undertaken and the intensity of training. Improvements in aerobic training will occur in about six weeks, but a greater amount of improvement is generally seen in about 12 weeks of training. Anaerobic training improvements are quite noticeable in about 6–8 weeks of training.

FIGURE 11.10 It is important to time the length of each work interval in order to achieve the appropriate fitness adaptations.

TABLE 11.2 Suggested guidelines for applying the training principles to aerobic and anaerobic training programs

Training principle	Aerobic training	Anaerobic training
Duration	6 weeks minimum 12–16 weeks	6 weeks minimum 8 weeks
Frequency	3–7 times per week	3–5 times per week
Intensity	70–85 per cent MHR	85–100 per cent MHR

Frequency

Frequency refers to the number of training sessions needed per week to ensure improvements are achieved in the desired fitness components and energy systems.

Generally the minimum number of training sessions per week for fitness gains to be possible is three. It is also generally acknowledged that to at least maintain a level of fitness, two training sessions per week are required.

An important consideration with **frequency** is the actual recovery time given following an exercise session before a similar session is undertaken. Other factors include the nature of the activity, the fitness level of the individual and the recovery facilities available.

Early in a training program, a positive training session may be followed by a poor or flat effort, usually because the untrained muscle has not recovered for the next exercise bout. Similarly, high-intensity and contact activities require longer recovery periods than needed for submaximal aerobic-type activity. This rule applies through to elite-level competition.

Therefore, the formula for gaining fitness is not to train as often as possible, but to find a balance between training frequency and recovery.

The minimum training frequency for improving aerobic fitness is three times per week, with up to five sessions being normal. Training can be even more frequent as the athletes aerobic fitness increases, especially for elite long-distance athletes. Simon Gerrans, one of Australia's most successful road cyclists, generally trains two long days (4–5hrs), three × three-hour rides with intervals and two easy days per week.

FIGURE 11.11 Road cyclist Simon Gerrans (right) of team Orica-GreenEdge narrowly wins stage 3 of the 2016 Tour Down Under.

The minimum frequency for improving anaerobic fitness, including strength and power, is also three sessions per week, with four being normal as the individual consolidates. The nature and intensity of this type of activity means that muscle recovery is a more important factor, and it must be planned as an integral aspect of the training program.

You can certainly have too many training sessions per week, but you can also have too few.

TEST your understanding

1. Describe the three meanings of the principle of time/duration.
2. State the minimum time in which the heart rate should be in the required training zone for continuous training.
3. State what is generally recognised as the minimum number of weeks for a training program to show measurable fitness gains.
4. Outline how often you should train if you just want to maintain a certain level of fitness.
5. Evaluate whether there should be more recovery between aerobic or anaerobic training sessions.

APPLY your understanding

6. To show measurable fitness gains, does the duration of a training program vary according to your targeted energy systems? If so, in what way?

EXAM practice

7. **(ACHPER Trial Exam 2010, question 2)**

Austin is 16 years old and has been training for his school's 5-km cross country. The majority of his training involves continuous running sessions of between four and six kilometres. Every fortnight, he substitutes one running session for a 20-km bike ride.

(a) Identify two training principles evident in Austin's training. **2 marks**

(b) Differentiate the role of each of these training principles in helping to prepare Austin for his school's cross country. **2 marks**

(c) Justify which training principle identified in part (b) you believe to be more important to successful performance. **2 marks**

(d) To evaluate the effectiveness of this training program, outline two other training principles you would require other than those mentioned in part (a). **2 marks**

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Unit 4	**Frequency and intensity**
AOS 2	Summary screen and practice questions
Topic 2	
Concept 1	

11.3 Progression (progressive overload), overtraining and variety

KEY CONCEPT Progressive overload is crucial to improving fitness and performance and variety is essential in maintaining motivation.

Progressive overload

Progression is the systematic application of overload (progressive overload) in order to achieve the adaptations required to improve performance.

There can be no improvement in personal fitness levels without progressively increasing or overloading the existing training levels. The new levels of physical activity must exceed the level to which the individual is already accustomed. Any overload of physical activity is controlled by the manipulation of the FITT principle (Frequency, Intensity, Time, Type of exercise) which have already been discussed in this chapter.

The human body responds to stress caused by physical work. Consequently, it adapts to cope with this stress or increased workload. Otherwise, there is a plateau in performance levels.

Progressive overload relies on four factors:

1. the existing workload is appropriate to the level of the individual's fitness
2. the amount of overload is sufficient to cause adaptation and improvement without causing the individual to feel unable to complete the session
3. the overload maintains the original aims of training
4. the variables of training (listed below) are not all revised at the one time, but rather, only one or possibly two variables are adjusted for the one session. This should lessen the chances of physical fatigue or joint and muscle soreness.

The variables of training that are available for progressive overload are:

- distance of work
- duration of work
- duration of recovery periods
- number of repetitions
- number of sets
- number of sessions per week
- amount of resistance
- range of motion.

The chosen variable must be manipulated for overload in a way that is consistent with the aim of the program. For example, an athlete aiming to improve their ATP–CP energy system by completing 5 × 70-metre running sprints could introduce overload by these methods:

- increase the number of repetitions of the 70-metre sprints
- moving from a 95 per cent effort sprint to a 100 per cent effort sprint
- increasing the distance sprinted, ensuring that the ATP–CP energy system remains the focused energy system.

This last point is crucial. If in this case the time of each sprint becomes longer and the effort moves from focusing on the ATP–CP system to focusing on the anaerobic glycolysis system, the overload will not continue to meet the aim of the training program.

The section on training methods later in this chapter further examines the more specific manipulation of variables for applying progressive overload. Progressive overload should be planned, but its application must be flexible. It may need to be applied after the first session if the prescription for the initial training bout is too low, or it may take several sessions. Progressive overload is particular to each individual and rigid application to all participants will not maximise training benefits.

FIGURE 11.12 Cate Campbell's correct application of progressive overload in her training program allowed her to obtain the world record in the 100m freestyle at the 2016 Australian Swimming Grand Prix.

It is vital that the application of progressive overload is gradual and systematic, allowing for appropriate adaptations to occur and to avoid overtraining. It is generally accepted that a variable is increased by two to 10 per cent.

Overtraining

Overtraining occurs when there is a long-term decline in performance and physical functioning. The ability of the body to continue to adapt to the training load is compromised when overtraining symptoms occur. Research suggests that there are both psychological and physiological causes of overtraining. Everyone will experience some level of fatigue following intense bouts of training, however overtraining is categorised by a decline in performance that cannot be remedied by a few days' rest.

While overtraining usually occurs when the amount and quality of recovery time is insufficient to fully recover from the stresses of training, there can be a number of other causes. These include:

- excessive training volume; for example, several training sessions every day of the week
- inappropriate increases in the frequency, duration and/or intensity of training; in other words, too much overload
- training when suffering from illness
- excessive increases in training loads following periods of enforced lay-off due to injury or illness
- excessive competition scheduling with maximum demands and frequent disturbance of daily routines
- poor nutritional state, especially inadequate carbohydrate, vitamin and mineral intake
- external stressors such as work and study demands, family responsibilities or difficulties in personal relationships.

It is important that adolescents who are physically active be aware of the dangers of overtraining a growing body.

The signs and symptoms of overtraining are listed in table 11.3 below and it is likely that they will vary according to the type of training undertaken.

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Unit 4 AOS 2 Topic 2 Concept 3
Progression and diminishing returns
Summary screen and practice questions

TABLE 11.3 Symptoms of overtraining

Physiological symptoms	Psychological symptoms	Miscellaneous symptoms
Persistent feelings of fatigue Chronic muscle soreness Increased or decreased morning resting heart rate (beyond normal variation) Increased heart rate during sub-maximal exercise at a given workload (beyond normal values) Earlier onset of fatigue during exercise bouts Decreased performance during strength and power testing Decreased coordination and disturbances in rhythm of movement	Decreased concentration span Decreased motivation levels Increased irritability and anger Depression Increased anxiety levels Increased fear of competition Increased sensitivity to emotional stress Increasing tendency to give up and believe that the challenge is too difficult Increased susceptibility to demoralising influences before and during competition	More frequent illnesses Loss of appetite Increase in overuse injuries Insomnia Lack of enjoyment of training and competition

The key to avoiding overtraining is prevention. Well-planned training programs that include adequate rest and recovery periods are essential, as are gradual increases in training loads. The periodisation of training in which the training load varies in cycles with built-in mandatory rest phases is also a key factor in the avoidance of overtraining. Appropriate recovery methods are also important in ensuring that athletes gain maximum effectiveness from recovery sessions and rest periods. Tools

such as training diaries, digital activity trackers and apps (outlined in chapter 10) are strategies that athletes can use to monitor their training stress and other training variables. Other recommendations for the prevention of overtraining include avoiding monotonous training by including some variety within the training program and also maintaining adequate nutrition. Vigorous exercise during the incubation period of a viral illness (e.g. the flu) may increase the duration and severity of that illness. Athletes who feel as if they are developing a cold should rest or reduce their training schedule for a few days.

If overtraining has occurred, the cure is relatively straightforward — reduce training loads and increase rest periods. A period of complete rest may be recommended. The longer the period of overtraining, generally the longer the period of time needed for recovery.

FIGURE 11.13 Digital activity trackers and apps are useful tools in preventing overtraining.

Variety

Variety is about providing different activities, formats and drills in training, while still addressing the aims of the training program. Its focus is to maintain the motivation levels of the performer and thereby optimise their fitness gains.

Training can become boring, and the athlete may drop out of the program if there is insufficient **variety**. Changes to training activities and drills stimulate and challenge participants, who are therefore more likely to train at optimal levels. But the use of variety must not diverge from the initial aims of the program.

Some examples of implementing variety include:

- Continuous training could be held at different venues or courses. This variable would work regardless of whether the continuous training was for running, cycling or swimming.
- Continuous running or cycling training could move venues to incorporate carefully introduced hill work.
- Continuous training sessions for one skill could be occasionally replaced with continuous sessions of running, cycling, swimming or even triathlons or biathlons.
- A program of resistance training could occasionally substitute free weights for machine weights or include a 'pump' or 'powerbar' session at the gym.
- A resistance training session could vary the order of exercise stations.
- Coaches should always be trying to vary warm-ups, drills and other aspects of their training sessions to promote enjoyment and improve the focus of their athletes.

studyon
Unit 4 AOS 2 Topic 2 Concept 4
Variety, specificity and individuality
Summary screen and practice questions

TEST your understanding

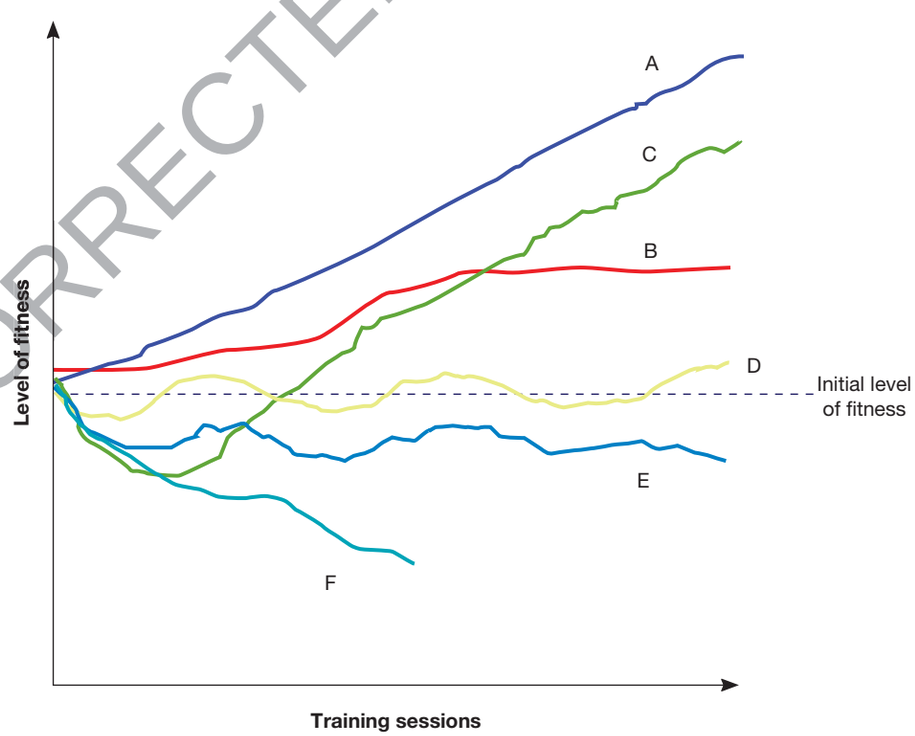
1 Define progressive overload.
2 Outline why it is important that overload is applied progressively.
3 Name the four factors on which overload relies.
4 Identify the variables with which training programs can be overloaded.
5 Define variety.
6 Explain the concept of overtraining.
7 List some of the signs and symptoms of overtraining.

APPLY your understanding

8 In the following training scenarios, suggest ways in which an athlete could introduce overload.
   (a) An 800-metre elite runner: one set of 6 × 300-metre intervals run at 75 per cent MHR with 1-minute walk recoveries between efforts
   (b) A 10 000-metre runner: three sessions per week of 15-kilometre runs around her local suburban streets
   (c) A pole vaulter: five sessions per week of two sets of 10 × 20-metre track sprints at 98 per cent MHR with 60 seconds of rest recovery between efforts and 10 minutes of walk recovery between sets
9 For the following sports, suggest ways in which variety could be introduced to training sessions: netball, swimming, tennis, basketball, water polo, cross-country running.
10 Examine the graph below and explain the progress of each of the six subjects in their application of progressive overload. Consider:
   (a) the appropriateness of the initial training load
   (b) adjustments made to the training load
   (c) no change to the training load
   (d) implications of a training load that is too easy or too hard.
11 Explain the factors that you would incorporate into your training program design that would prevent the likelihood of overtraining occurring.

EXAM practice

12 An athlete can use a variety of measures to monitor their progress. Oliver has felt ongoing fatigue during training. His coach refers to Oliver's training diary to gain a better understanding as to what might be causing the fatigue. She notices the following patterns in the recording of his daily information: ongoing muscle soreness, higher resting heart rates, lack of enjoyment, disturbed sleep patterns and a limited concentration span.
   (a) What do these symptoms indicate is occurring to Oliver? **1 mark**
   (b) Outline two factors that may have led to Oliver's ongoing fatigue. **2 marks**
   (c) Provide a recommendation as to how Oliver could best overcome this ongoing fatigue. **1 mark**
   (d) Explain how Oliver's coach could prevent him from developing ongoing fatigue in the future. **3 marks**



11.4 Diminishing returns, reversibility or de-training, maintenance and individuality

KEY CONCEPT All training principles need to be considered in the design of an effective training program.

Diminishing returns

Fitness gains and improvements in performance occur most rapidly during the early stages of undertaking a training program and smaller margins of improvement occur as a person nears their optimal level of fitness and performance.

As an individuals fitness level increases, the rate of improvement lessens, thus creating **diminishing returns**. Someone who is unfit can make a large improvement in the first few weeks of a training program, while someone who is already fit can make only progressive, small gains despite training at a high level. An unfit older adolescent or adult sprinter who initially takes 16 seconds to sprint 100 metres may rapidly reduce their time to 11.5 seconds, but improvement from this point will take longer and be measured in tenths or hundredths of a second.

The law of **diminishing returns** states that the rate of fitness improvement diminishes as a person approaches their genetic potential.

The application of overload must be kept in perspective as an individual reaches peak levels of fitness. When the athletes improvement begins to plateau, large or increasing amounts of overload may lead to injury or fatigue and loss of fitness.

The principle of diminishing returns suggests the rate of fitness gains diminishes over time as individuals approach their ultimate genetic potential (figure 11.14). Simply stated, as fitness improves, maintained levels of improvement cannot be expected. The fitter individuals are, the less likely they are to improve further.

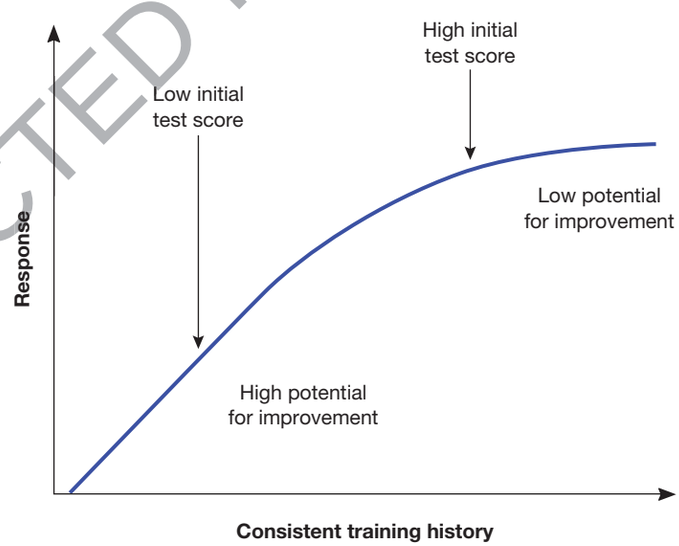


FIGURE 11.14 Recent training history determines an individual's future responsiveness to physical training.

Reversibility or detraining

When training stops or is reduced, the reversal of fitness gains occurs much more quickly than they were achieved. The extent of performance loss is dependent upon the length of the **detraining** and the type of activity. Generally, aerobic endurance gains are lost quickly, in the first two to four weeks, while muscular strength degeneration tends to be much slower. Research has found that aerobic capacity declines between 4 and 20% during the initial eight weeks of detraining and the degree of **reversibility** tends to be greater in highly trained aerobic athletes.

Detraining is a period of time when training is ceased or there is a reduction in training load beyond what is required for fitness to be maintained.

Reversibility describes the fitness and/or performance loss after a period of detraining.

The extent of decline in strength and power during a period of detraining is dependent upon training experience, the length of training time prior to detraining and specific muscle groups. Izquierdo and colleagues (2007) found a decrease of 6% in squat strength and a decrease of 9% in bench press strength following a four-week detraining period in athletes who had undertaken a 16-week resistance training program.

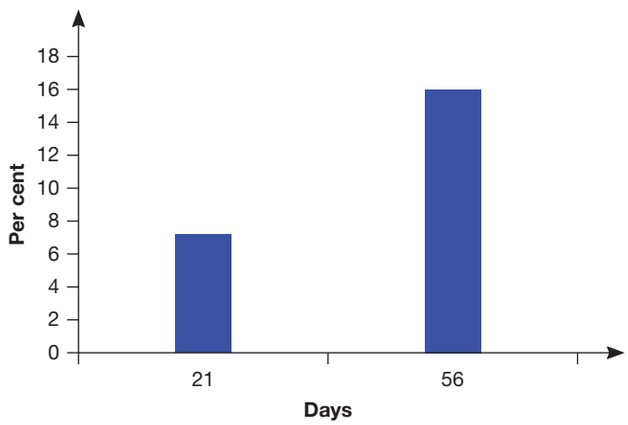


FIGURE 11.15 Loss of aerobic capacity dependant on duration of detraining period

This principle suggests that consistency and regularity of physical activity are critical determinants of both fitness maintenance and improvement. All the hard work put in over weeks of training to make measurable fitness gains can be easily reversed in just a couple of weeks.

Maintenance

Acquired fitness levels can be **maintained** by carefully altering the FITT principle (Frequency, Intensity, Time, Type of exercise).

By maintaining the intensity of training and decreasing the volume or frequency of training by around one-third, the attained fitness levels should be maintained. The amount of reduction of training load will be different from one person to the next.

A general understanding is that moving from a minimum of three quality training sessions per week to two should maintain an attained level of fitness. The training intensity is vital for maintaining fitness and performance. The principle of reversibility supports the saying 'use it or lose it' and therefore a strategic approach to training must be undertaken in order to maintain current fitness levels.

The principle of **maintenance** suggests that once a required level of fitness has been achieved, the level of effort to maintain that level of fitness is not as great as was required to achieve it.

Individuality

No two individuals react in exactly the same way to a similar physical activity program. Regardless of the training programs being used, some people will achieve significant gains, while others will only improve slowly.

The principle of **individuality** is strongly influenced by heredity.

The principle of **individuality** suggests that individual responses to physical activity are highly varied.

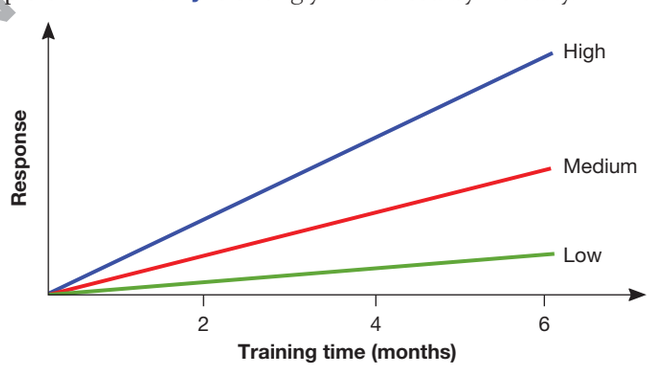


FIGURE 11.16 Individual response to training varies widely.

Source: Bouchard, C & Rankinen, T 2001, 'Individual differences in response to regular physical activity', *Medicine and Science in Sports and Exercise,* vol. 33, no. 6, pp. S446–S451.

11.4 Diminishing returns, reversibility or de-training, maintenance and individuality

It is essential that a training program is designed to cater for the specific needs, goals and abilities of the individual.

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Unit 4	**Maintenance, over training and detraining**
AOS 2	
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TEST your understanding

1. Outline what other training principle is important to consider when a training program begins to show signs of diminishing returns.
2. Define the principle of reversibility.
3. Explain what the term detraining means.
4. Identify which of the FITT factors must stay the same if maintenance of training gains is desired.
5. Define the principle of individuality.

APPLY your understanding

6. Are there differences in the speed of reversibility of fitness gains between aerobic and anaerobic training programs? Explain these.
7. Discuss how a training program can be adapted to delay the principle of reversibility.
8. For the following training scenario suggest ways to adjust the FITT factors to allow this athlete to achieve maintenance.
   A pole vaulter: five sessions per week of two sets of 10 × 20-metre track sprints at 98 per cent MHR with 60 seconds of rest recovery between efforts and 10 minutes of walk recovery between sets.
9. Discuss how a trainer or coach prepares for the effects of the principle of individuality on each of their participants in a training program.

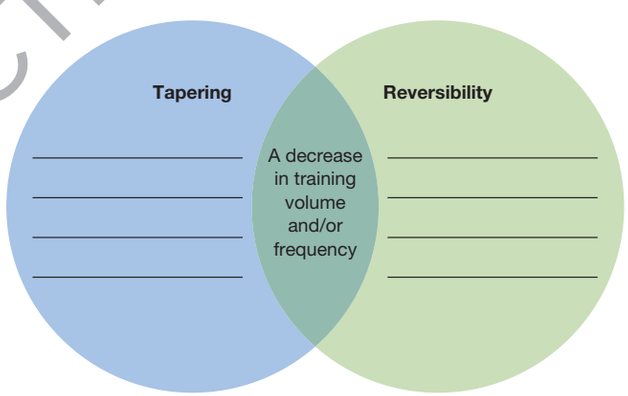
EXAM practice

10 **(ACHPER Trial Exam 2011, question 11)**

Outline two training principles a coach should ensure his or her athletes are aware of during their 'off season'. **2 marks**

11 **(adapted from ACHPER Trial Exam 2012, question 2)**

Tapering and reversibility may be demonstrated within a training program. Complete the Venn diagram below to distinguish between tapering and reversibility.



2 marks

11.5 Continuous and interval training

KEY CONCEPT Both continuous and interval training provide benefits in improving performance, however they each achieve this differently.

Continuous training

Continuous training leads to an improvement in aerobic capacity and local muscular endurance, and improves the lactate inflection point. You reach your aerobic steady state faster, accumulate lactic acid more slowly and recover more quickly.

This type of training can be adapted to any activity that requires the use of the aerobic energy system as the dominant provider of ATP. It is not restricted to running; continuous training can also be applied to swimming, cycling, cross-country skiing and kayaking, for example:

- a 5-kilometre run
- a 500-metre swim
- a 20-kilometre bike ride
- a 5-kilometre cross-country skiing trip
- a 2-kilometre rowing session.

Continuous training is also commonly used in team sports as a pre-season training method to establish a sound aerobic base from which athletes improve their other fitness components and in the off-season for the purpose of aerobic maintenance.

To gain the most out of continuous training, follow the FITT formula:

- Frequency (at least three sessions per week for aerobic improvements)
- Intensity (in the aerobic training zone between 70–85% MHR as indicated in figure 11.5)
- Time (minimum of 20 minutes continuous activity is required)
- Type (whole-body activities that use large, major muscle groups, such as walking, running, cycling, rowing, swimming and aerobics). All aspects of the FITT formula should be used.

Also often known as long, slow distance training, **continuous training** involves continuous activity that lasts a minimum of 20 minutes at the required intensity using the aerobic energy system. It is submaximal and requires an intensity of 70–85 per cent of maximum heart rate.

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Unit 4	**Continuous and fartlek training**
AOS 2	Summary screen and practice questions
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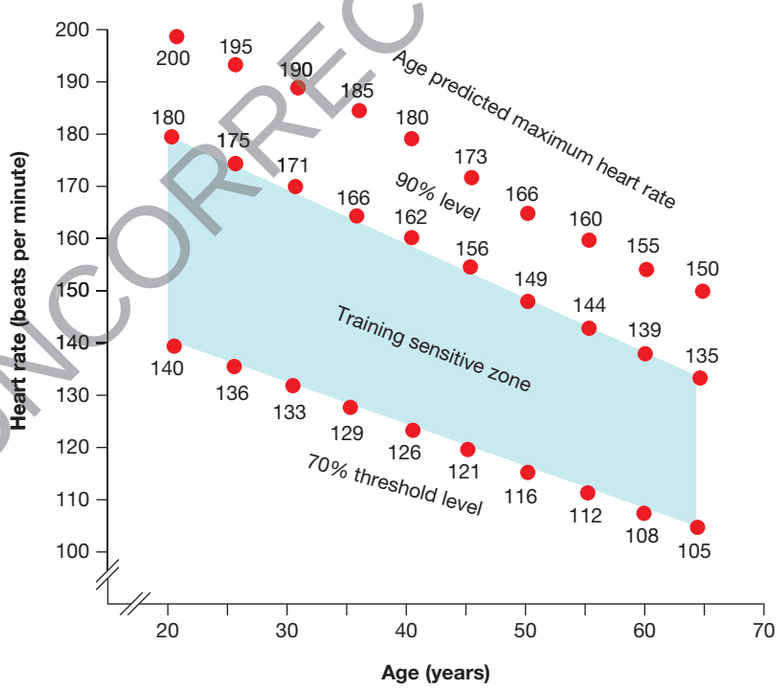

FIGURE 11.17 Target training zone for aerobic fitness improvement

Long, slow distance training is generally the most common and safest type of training adopted by recreational athletes in order to attain health-related benefits.

It is important to note that continuous training can also include high-intensity endurance training that is performed at intensities of 85–95% MHR. The purpose of high-intensity endurance training is to perform at intensities that allow the athlete to improve their lactate inflection point.

Interval training

Interval training consists of repeated periods of work followed by periods of rest or recovery

Interval training consists of repeated periods of work followed by periods of rest or recovery.

Interval training is a versatile training method that can be tailored to the specific energy system needs. It requires careful planning, and several variables must be considered when planning both the initial exercise bout and the application of progressive overload (table 11.4).

TABLE 11.4 Planning interval training

Variable	Description	Examples
Work interval distance	The distance of the work	60 metres
Work interval time	The time in which the work must be completed	8 seconds
Rest interval duration	The time between work intervals	40 seconds
Rest interval type	The nature of the rest between work intervals	Walk
Work intensity	How hard the work is to be done (usually a percentage of the maximum heart rate)	95 per cent
Repetitions	The number of work periods in a sequence	8
Sets	The number of repetition sequences	3
Frequency	The number of training sessions per week	3

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Unit 4
AOS 2
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Concept 2
Short interval training
Summary screen and practice questions

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Unit 4
AOS 2
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Concept 3
Long interval training
Summary screen and practice questions

Interval training and work to rest ratio

In planning interval training, a knowledge of the work-to-rest ratio is important because this determines the setting of the variables. The work-to-rest ratio is established by analysing and breaking an activity into work and rest components. It indicates how much work is completed in an activity in proportion to how much rest is available.

An important fact to establish is what is classified as work and what is classified as rest.

Although work-to-rest ratios cannot be used in isolation to determine energy system usage, the following examples show the general relationship:

- A work-to-rest ratio of 1:5 and greater indicates that the ATP–CP energy system is the system predominantly used.
- A ratio of 1:3 would suggest the use of the anaerobic glycolysis energy system.
- A ratio of 1:1 would use aerobic energy.

Once the work-to-rest ratio is established for an activity, it can be replicated in the interval training schedule (the principle of specificity). Examples of interval training for the three energy systems are outlined in table 11.5.

TABLE 11.5 Examples of interval training variables for running

Type of interval training	Energy system	Work interval time	Work intensity	Reps	Sets	Rest/recovery interval time	Work:rest ratio	Training frequency per week
Short	ATP–CP	3–10 sec	Maximal	6–15	3	3–50 sec	1:5+	3
Intermediate	Anaerobic glycolysis	10–60 sec	85%–95% of max HR	6–10	2	30–180 sec	1:3	3
Long	Aerobic	30 sec–4 min	70–85(+)% of max HR	2–4	2	30 sec–4 min	1:1 1:0 2:1	4–5

With sports science's understanding of the contribution of the energy systems to athletic performance, we now acknowledge that interval training can facilitate the development of all three energy systems, depending upon how the variables are manipulated.

Long-interval training has traditionally been the type of interval training adopted in order to improve aerobic power, however there has been growing evidence that suggests that **high-intensity interval training (HIIT)** is a very time-efficient training method to elicit chronic aerobic adaptations. HIIT involves repeated work intervals with sessions that are relatively brief in duration, performed at a high level of intensity close to VO_2 maximum. A single work interval may be a few seconds to several minutes in duration, separated by up to a few minutes of rest or recovery exercise.

Research indicates that for athletes who already have a high level of aerobic capacity, further improvements are best obtained through high-intensity interval training.

FIGURE 11.18 HIIT training session on cycle ergometer

TABLE 11.6 A typical example of a HIIT training program on a cycle ergometer

Work interval time	Work intensity	Reps	Sets	Rest/ recovery time	Frequency
30 seconds	Maximum	4–6	1	2–3 minutes	3 per week

Total work period for each training session = 2–3 minutes
Total training session time including rest/recovery time = 20 minutes.

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Unit 4	**Long interval training**
AOS 2	Summary screen and practice questions
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High-intensity interval training (HIIT) involves repeated work intervals that are relatively brief in duration, performed at a high level of intensity close to VO_2 maximum followed by less intense recovery/rest intervals.

The American College of Sports Medicine (ACSM) provides further information about HIIT training;

ACSM information on…
HIGH-INTENSITY INTERVAL TRAINING

The popularity of high intensity interval training is on the rise. High intensity interval training sessions are commonly called HIIT workouts. This type of training involves repeated bouts of high intensity effort followed by varied recovery times.

A complete physical activity program
A well-rounded physical activity program includes aerobic exercise and strength training exercise, but not necessarily in the same session. This blend helps maintain or improve cardiorespiratory and muscular fitness and overall health and function. Regular physical activity will provide more health benefits than sporadic, high intensity workouts, so choose exercises you are likely to enjoy and that you can incorporate into your schedule.

ACSM's physical activity recommendations for healthy adults, updated in 2011, recommend at least 30 minutes of moderate-intensity physical activity (working hard enough to break a sweat, but still able to carry on a conversation) five days per week, or 20 minutes of more vigorous activity three days per week. Combinations of moderate- and vigorous-intensity activity can be performed to meet this recommendation.

Examples of typical aerobic exercises are:

- Walking
- Running
- Stair climbing
- Cycling
- Rowing
- Cross-country skiing
- Swimming

In addition, strength training should be performed a minimum of two days each week, with 8-12 repetitions of 8-10 different exercises that target all major muscle groups. This type of training can be accomplished using body weight, resistance bands, free weights, medicine balls or weight machines.

The intense work periods may range from 5 seconds to 8 minutes long, and are performed at 80% to 95% of a person's estimated maximal heart rate, the maximum number of times your heart will beat in a minute without overexerting yourself. The recovery periods may last equally as long as the work periods and are usually performed at 40% to 50% of a person's estimated maximal heart rate. The workout continues with the alternating work and relief periods totaling 20 to 60 minutes.

What are the benefits of HIIT?
HIIT training has been shown to improve:

- aerobic and anaerobic fitness
- blood pressure
- cardiovascular health
- insulin sensitivity (which helps the exercising muscles more readily use glucose for fuel to make energy)
- cholesterol profiles
- abdominal fat and body weight while maintaining muscle mass.

Why is HIIT training so popular?
HIIT training can easily be modified for people of all fitness levels and special conditions, such as overweight and diabetes. HIIT workouts can be performed on all exercise modes, including cycling, walking, swimming, aqua training, elliptical cross-training, and in many group exercise classes. HIIT workouts provide similar fitness benefits as continuous endurance workouts, but in shorter periods of time. This is because HIIT workouts tend to burn more calories than traditional workouts, especially after the workout. The post-exercise period is called "EPOC", which stands for excess postexercise oxygen consumption. This is generally about a 2-hour period after an exercise bout where the body is restoring itself to pre-exercise levels, and thus using more energy. Because of the vigorous contractile nature of HIIT workouts, the EPOC generally tends to be modestly greater, adding about 6 to 15% more calories to the overall workout energy expenditure.

How do you develop a HIIT exercise program?
When developing a HIIT program, consider the duration, intensity, and frequency of the work intervals and the length of the recovery intervals. Intensity during the high intensity work interval should range ≥ 80% of your estimated maximal heart rate. As a good subjective indicator, the work interval should feel like you are exercising "hard" to "very hard". Using the talk test as your guide, it would be like carrying on a conversation, with difficulty. The intensity of the recovery interval should be 40-50% of your estimate maximal heart rate. This would be a physical activity that felt very comfortable, in order to help you recover and prepare for your next work interval.

The relationship of the work and recovery interval is important. Many studies use a specific ratio of exercise to recovery to improve the different energy systems of the body. For example, a ratio of 1:1 might be a 3-minute hard work (or high intensity) bout followed by a 3-minute recovery (or low intensity) bout. These 1:1 interval workouts often range about 3, 4, or 5 minutes followed by an equal time in recovery. Another popular HIIT training protocol is called the "spring interval training method". With this type of program the exerciser does about 30 seconds of 'sprint or near full-out effort', which is followed by 4 to 4.5 minutes of recovery. This combination of exercise can be repeated 3 to 5 times. These higher intensity work efforts are typically shorter bouts (30 seconds with sprint interval training).

What are the safety concerns with HIIT training?
Persons who have been living rather sedentary lifestyles or periods of physical inactivity may have an increased coronary disease risk to high intensity exercise. Family history, cigarette smoking, hypertension, diabetes (or pre-diabetes), abnormal cholesterol levels and obesity will increase this risk. Medical clearance from a physician may be an appropriate safety measure for anyone with these conditions before staring HIIT or any exercise training. Prior to beginning HIIT training a person is encouraged to establish a foundational level of fitness. This foundation is sometimes referred to as a "base fitness level". A base fitness level is consistent aerobic training (3 to 5 times a week for 20 to 60 min per session at a somewhat hard

intensity) for several weeks that produces muscular adaptations, which improve oxygen transport to the muscles. Establishing appropriate exercise form and muscle strength are important before engaging in regular HIIT to reduce the risk of musculoskeletal injury.

Regardless of age, gender and fitness level, one of the keys to safe participation of HIIT training is for all people to modify the intensity of the work interval to a preferred challenging level. Safety in participation should always be primary priority, and people should focus more on finding their own optimal training intensities as opposed to keeping up with other persons.

How many times a week can you do a HIIT workout?
HIIT workouts are more exhaustive then steady state endurance workouts. Therefore, a longer recovery period is often needed. Perhaps start with one HIIT training workout a week, with your other workouts being steady state workouts. As you feel ready for more challenge, add a second HIIT workout a week, making sure you spread the HIIT workouts throughout the week.

Final HIIT message
Interval training has been an integral part of athletic training programs for many years because a variety of sport and recreational activities require short bursts of movement at high intensities. Interval training is becoming an increasingly recognized and well-liked method of training. The incorporation of interval training into a general conditioning program will optimize the development of cardiorespiratory fitness as well as numerous other health benefits. Give HIIT a try.

Staying active pays off!
Those who are physically active tend to live longer, healthier lives. Research shows that moderate physical activity – such as 30 minutes a day of brisk walking – significantly contributes to longevity. Even a person with risk factors like high blood pressure, diabetes or even a smoking habit can gain real benefits from incorporating regular physical activity into their daily life.

As many dieters have found, exercise can help you stay on a diet and lose weight. What's more – regular exercise can help lower blood pressure, control blood sugar, improve cholesterol levels and build stronger, denser bones.

The first step
Before you begin an exercise program, take a fitness test, or substantially increase your level of activity, make sure to answer the following questions. This physical activity readiness questionnaire (PAR-Q) will help determine if you're ready to begin an exercise routine or program.

- Has your doctor ever said that you have a heart condition or that you should participate in physical activity only as recommended by a doctor?
- Do you feel pain in your chest during physical activity?
- In the past month, have you had chest pain when you were not doing physical activity?
- Do you lose your balance from dizziness? Do you ever lose consciousness?
- Do you have a bone or joint problem that could be made worse by a change in your physical activity?
- Is your doctor currently prescribing drugs for your blood pressure or a heart condition?
- Do you know of any reason you should not participate in physical activity?

If you answered yes to one or more questions, if you are over 40 years of age and have recently been inactive, or if you are concerned about your health, consult a physician before taking a fitness test or substantially increasing your physical activity. If you answered no to each question, then it's likely that you can safely begin exercising.

Prior to exercise
Prior to beginning any exercise program, including the activities depicted in this brochure, individuals should seek medical evaluation and clearance to engage in activity. Not all exercise programs are suitable for everyone, and some programs may result in injury. Activities should be carried out at a pace that is comfortable for the user. Users should discontinue participation in any exercise activity that causes pain or discomfort. In such event, medical consultation should be immediately obtained.

Brochure content provided by Len Kravitz, Ph.D.

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Unit 4 | AOS 2 | Topic 3 | Concept 5

High intensity interval training
Summary screen and practice questions

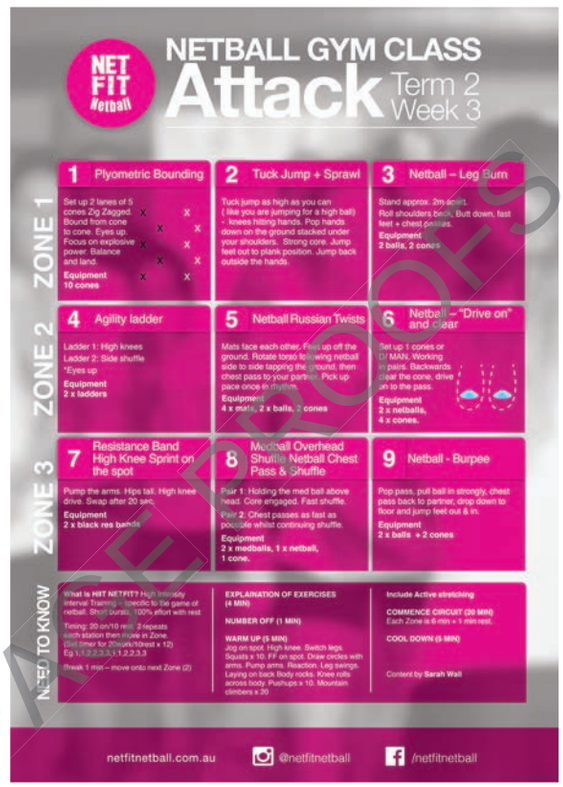
HIIT has been found to be a very time-efficient training method that enables skeletal muscle adaptations similar to those achieved by other forms of endurance training. In as little as two weeks including six sessions of HIIT, which encompasses a total of only 12–15 minutes of maximum-intensity work intervals, there can be increases in skeletal muscle oxidative capacity and noticeable improvements in performance during activities that require aerobic energy metabolism.

Interval training can and should be designed to cater for the particular requirements of the sport or activity for which the athlete is training. Sarah Wall, creator of NETFIT Netball, incorporates netball-specific skills and movements into a HIIT session as outlined in figure 11.19:

eBook*plus*

Weblink
Fit in 6 minutes a week

FIGURE 11.19 Netball specific HIIT session by NETFIT



Applying progressive overload to interval training

The training example used in table 11.5 could involve manipulating the following variables to overload:

- work interval distance
- work interval time
- rest interval time
- rest interval type
- number of repetitions
- number of sets.

However, it is also important to maintain the original aim of training. Table 11.7 summarises the impact of variable manipulation when applying progressive overload with the aim of improving ATP–CP energy system efficiency.

Many team sport coaches adopt interval training as the most effective means of conditioning athletes. For example, Australian Rules football teams long ago moved away from an emphasis on continuous training to interval work because the work-to-rest relationship closely resembles that of the game situation.

TABLE 11.7 The impact of variable manipulation

Variable	Current training	Manipulation to cause overload	Impact
Work interval distance	100 metres	Longer	Changes the predominant energy system to anaerobic glycolysis
Work interval time	15 seconds	Shorter	Creates higher intensity, requiring more phosphate energy
Rest interval time	45 seconds	Shorter	Changes the work-to-rest ratio to less than 1:3, so anaerobic glycolysis becomes the predominant energy system

Variable	Current training	Manipulation to cause overload	Impact
Rest interval type	Rest	Slow jog	Appropriate as long as the intensity of jogging remains low
Number of repetitions	8	Increase	Appropriate, although too many will lead to gradual depletion of adenosine triphosphate and reliance on anaerobic glycolysis
Number of sets	2	Increase	More appropriate than a continual increase in repetitions

TEST your understanding

1. Define the continuous training method.
2. Explain why continuous training is often the chosen method of training used for improving aerobic power in recreational athletes.
3. Outline the best ways to manipulate the FITT principle to promote effective continuous training.
4. Define interval training.
5. Outline the recommendations in the variables associated with short, intermediate and long interval training.
6. Reflect why it is beneficial to adopt HIIT as a method of improving aerobic power.

APPLY your understanding

7. Explain a scenario where continuous training would be the most appropriate training to adopt into a training program. Give reasons for your response.
8. (a) Choose a particular case study and design an appropriate interval (short, intermediate, long or high intensity) training program using the following variables:
   - work interval time
   - work intensity
   - number of reps
   - number of sets
   - rest/recovery time
   - work-to-rest ratio
   - frequency per week.

   (b) Justify the selection of each of the variables into your training program design.
9. Explain some ways in which you could incorporate variety into continuous and interval training program design.
10. **Practical activity: Interval training**
    Organise your class group to participate in an individual interval training session that would be appropriate to include in the training program you outlined in question 10.
11. **Practical activity: Continuous trainging**
    Participate in a 20-minute continuous training session, ensuring that your heart rate remains in the recommended target zone.

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Unit 4	**Circuit training** Summary screen and practice questions
AOS 2	
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EXAM practice

12 **(ACHPER Trial Exam 2010, question 15)**

(a) The following is an example of an interval training session. In the table below, fill in the rest period required for the anaerobic glycolysis energy system.

Energy system	Sets	Repetitions	Exercise	Work time (Secs)	Intensity	Rest time (Secs)
ATP-PC	2 (10 mins rest between each set)	6	50 m Sprints	7	Maximal	70 seconds
Anaerobic Glycolysis	2 (10 mins rest between each set)	6	50 m Sprints	7	High	

1 mark

(b) For the same program as in part (a), demonstrate how you would apply overload to the ATP–CP system by completing the following table.

Energy system	Sets	Repetitions	Exercise	Work time (Secs)	Intensity	Rest time (Secs)
ATP-PC	2 (10 mins rest between each set)	6	50 m Sprints	7	Maximal	70 seconds
ATP-PC						

1 mark

(c) Differentiate between sets and *repetitions*. **2 marks**

11.6 Resistance (or weight) training

KEY CONCEPT Resistance training improves the strength and functionality of skeletal muscles.

There are different types of **resistance training**:

- isoinertial (free weights)
- isometric (fixed resistance)
- isokinetic (variable resistance provided by a machine)
- eccentric overload training (flywheel and versapulley)
- core strength training (pilates and swissball).

Resistance training aims to build muscle strength, muscle power or local muscular endurance by exercising muscles or muscle groups against a resistance.

Isoinertial resistance training is the traditional form of resistance training, using free weights such as barbells and dumbbells, or resistance machines that use weight stacks for adjusting resistance. It is dynamic and involves lifting a set weight through the range of motion of the joint. This training has two distinct phases that can be completed independently of each other.

An **isoinertial** contraction is a type of dynamic muscle contraction where the resistance against the muscle remains constant.

These phases are:

- *the concentric phase*, where the muscle contracts against the force of gravity
- *the eccentric phase*, where the muscle lengthens under tension with the force of gravity.

The criticism of this method has been that the maximum weight that can be used in free weights is that which can be lifted at the weakest points (the start and finish) of the range of motion. Muscle is not being trained by an appropriate resistance in the mid-section of the lift (approximately 115 degrees), which is the strongest point of the contraction. For example, when lifting the weight in a bicep curl, at the start of the exercise, the weight of the dumbbell must be overcome. Initially the involved muscles contract isometrically in order to produce enough tension to begin to overcome the load of the dumbbell. As soon as the force produced by the muscle is greater than the resistance, the muscle contracts concentrically, and causes acceleration of the bicep curl exercise.

Isometric resistance training involves holding the muscle in one position while it contracts against the resistance. Tension in the muscle increases but the muscle stays the same length. Examples are pushing against a wall, performing a handstand and holding a crucifix (or Iron Cross) position on the Roman rings. This method is effective in increasing strength but only in the static position held, so it has minimal use in dynamic activities. If the arm, for example, is flexed at 90 degrees against an isometric resistance (see figure 11.21(a)) strength would improve for that position. Adjusting the flex to 120 degrees (see figure 11.21(b)) would produce isometric strength gain for that position only.

An **isometric** contraction is when the muscle length remains the same as it contracts under tension.

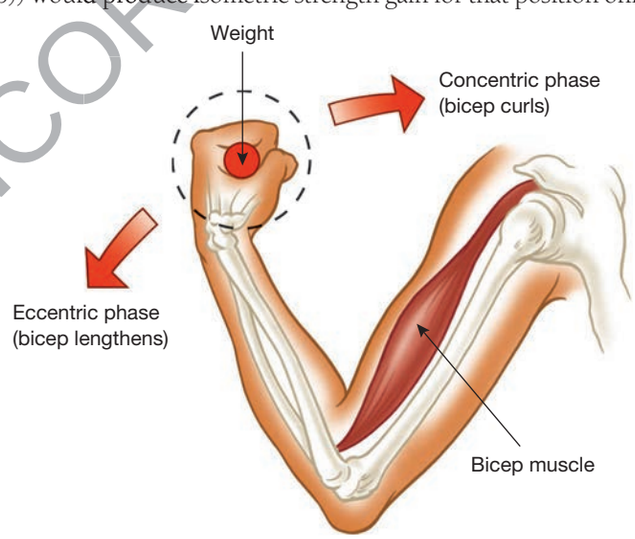

FIGURE 11.20 Concentric and eccentric phases of the biceps curl

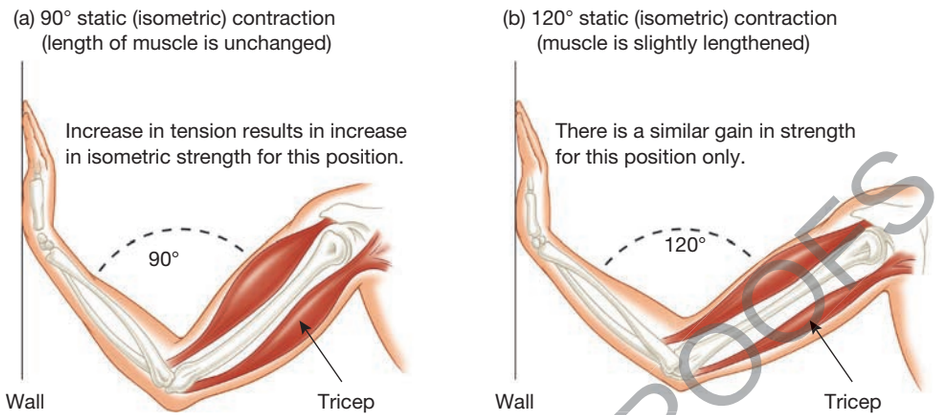

FIGURE 11.21(A) AND (B) The impact of isometric training on muscular strength for the tricep is limited to the angle of joint flexion.

You may be surprised at how often the sport you play requires some form of isometric strength. Whether it is gripping a racquet, ball or opponent, or just holding a particular body position, these movements all require isometric strength. Specific sporting examples where isometric strength is required and therefore would gain from this form of training are Olympic wrestling, rugby scrums, Australian Rules football tackling, rock-climbing, sailing, and sports that require grip and strength to hold equipment.

Isokinetic resistance training is undertaken on machines such as a Cybex, Kincom, Biodex or Hydragym, which can adjust the load as the body part moves through the range of motion. This is called accommodating resistance adjusting the resistance to a greater or lesser amount as the body parts work through the full range of motion.

Research shows that improvements in strength using isokinetic resistance training occur only at or below the velocity at which the resistance allows the joint to move. More advanced machines have adjustable resistance to allow higher velocity movements that result in greater benefits.

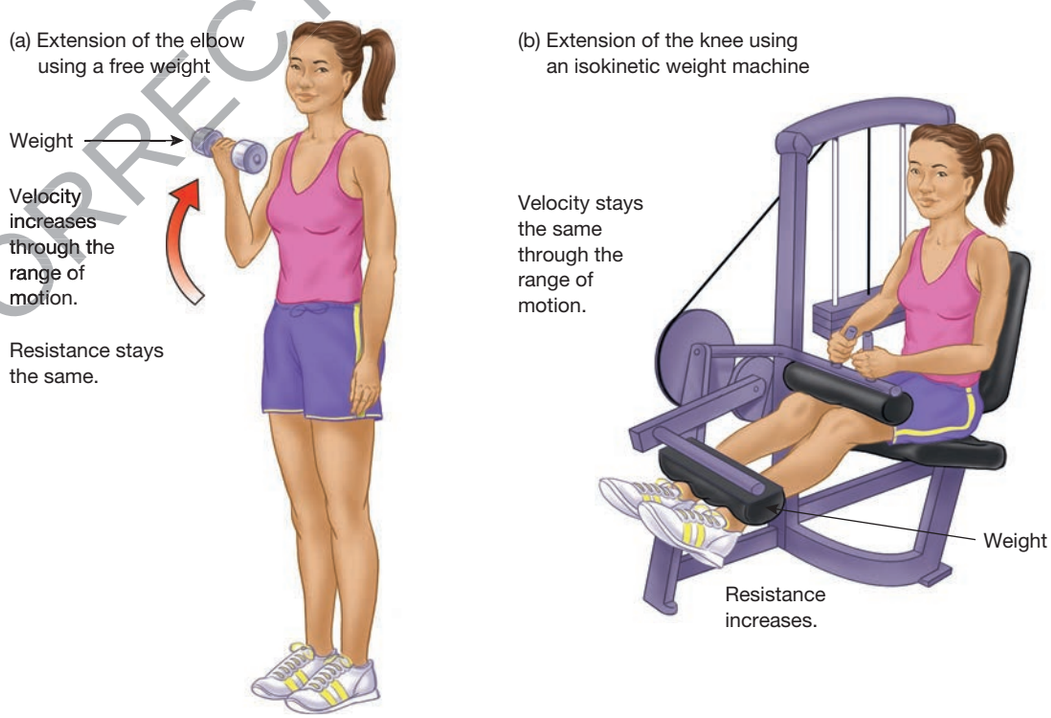

FIGURE 11.22 (A) AND (B) The difference between isointertial and isokinetic muscle contraction

Eccentric overload training is a form of dynamic resistance training that emphasises the eccentric phase of the muscle contraction. A resistance program that includes an emphasis on both eccentric and concentric contraction phases will maximise the gains in muscular strength and size. Flywheel and Versapulley technology allows for an isoinertial eccentric contraction overload as they work on the basis of inertia opposing the force exerted by the muscle rather than simply gravity see figure 11.23. Your muscles are generally stronger in the eccentric phase of contraction than the concentric phase of contraction. In standard loading resistance training, the maximal load can be lifted is limited by the concentric phase of contraction, and the eccentric phase of contraction is therefore underloaded. Eccentric overload training leads to greater neuromuscular and strength adaptations compared with standard loading.

An **eccentric** contraction is when the muscle lengthens as it contracts.

FIGURE 11.23 Eccentric training with inertia opposing the contraction

Core strength training

The aim of core strength (or stability) training is to effectively use the trunk musculature and to control the position of the lower back (or lumbar spine) during sport or recreation-based movements. The major abdominal and hip area muscles are central in the active support of the lumbar spine. The teamwork of these muscles stabilises the lumbar spine and acts directly to resist all the forces acting on the lumbar spine. The strength and coordination of these muscles is significant in creating a safe, successful and enjoyable movement. Improving the muscular strength of the postural muscles will reduce the risk of injury and improve performance. Strength of the core muscles becomes very important when fatigue sets in and form needs to be maintained in order to execute skills well. Core strength exercise should target the abdominals, gluteals and lumbar extensors.

As with all fitness training, the training procedure for core strength must be specific to the task required. The deep-trunk muscles act as stabilisers and provide isometric strength of varying degrees during all movements.

Some common core strength exercises are the plank, bridge and superman. Pilates, yoga and gym ball training all have a focus on strengthening core stability.

Core strength training should be undertaken 2–3 times per week and include rest days so as to allow muscle recovery. As core strength develops, the load can be gradually increased by increasing the number of repetitions, number of sets, the difficulty of each exercise or frequency of training.

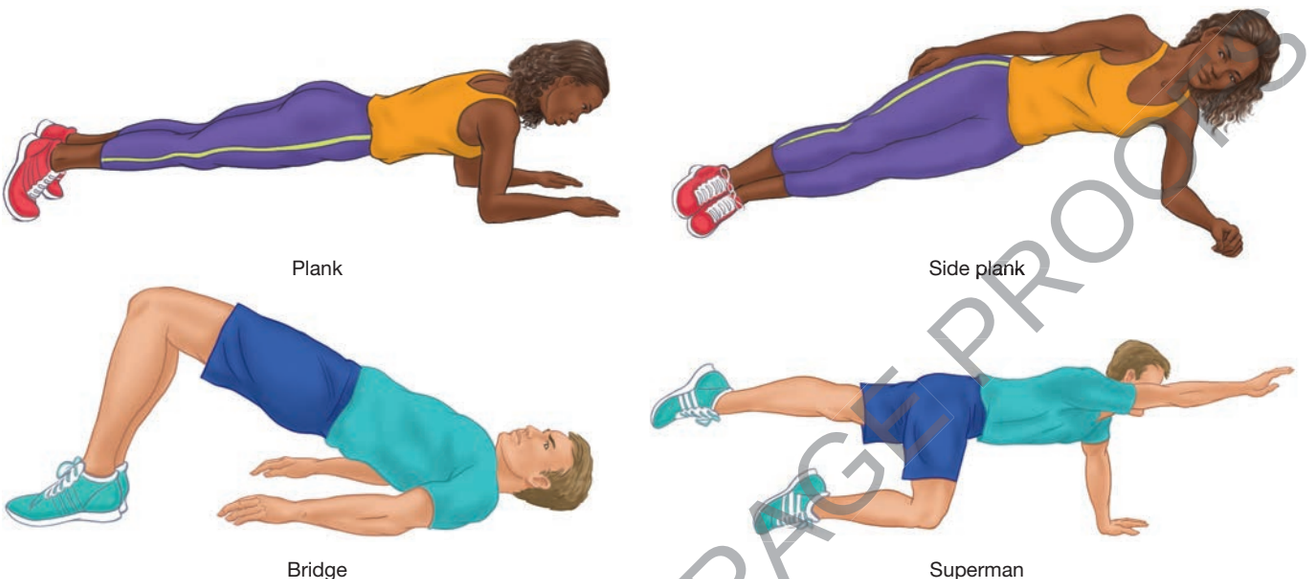

FIGURE 11.24 Core stability exercises can be performed with no or minimal equipment.

FIGURE 11.25 Core strength training with the assistance of a gym ball

Core stability has become recognised as an important part of modern fitness training philosophies. It is used by almost all elite sporting teams and individuals to heighten total body stability during competition.

Specificity in resistance training

One of the main reasons for resistance training being central to just about all sport training is that its movements can be designed to mimic most sporting actions. This means that muscles used in a movement, the energy systems employed in that movement, the angles of joint movement used and the force required for the movement can all be replicated in a resistance training exercise.

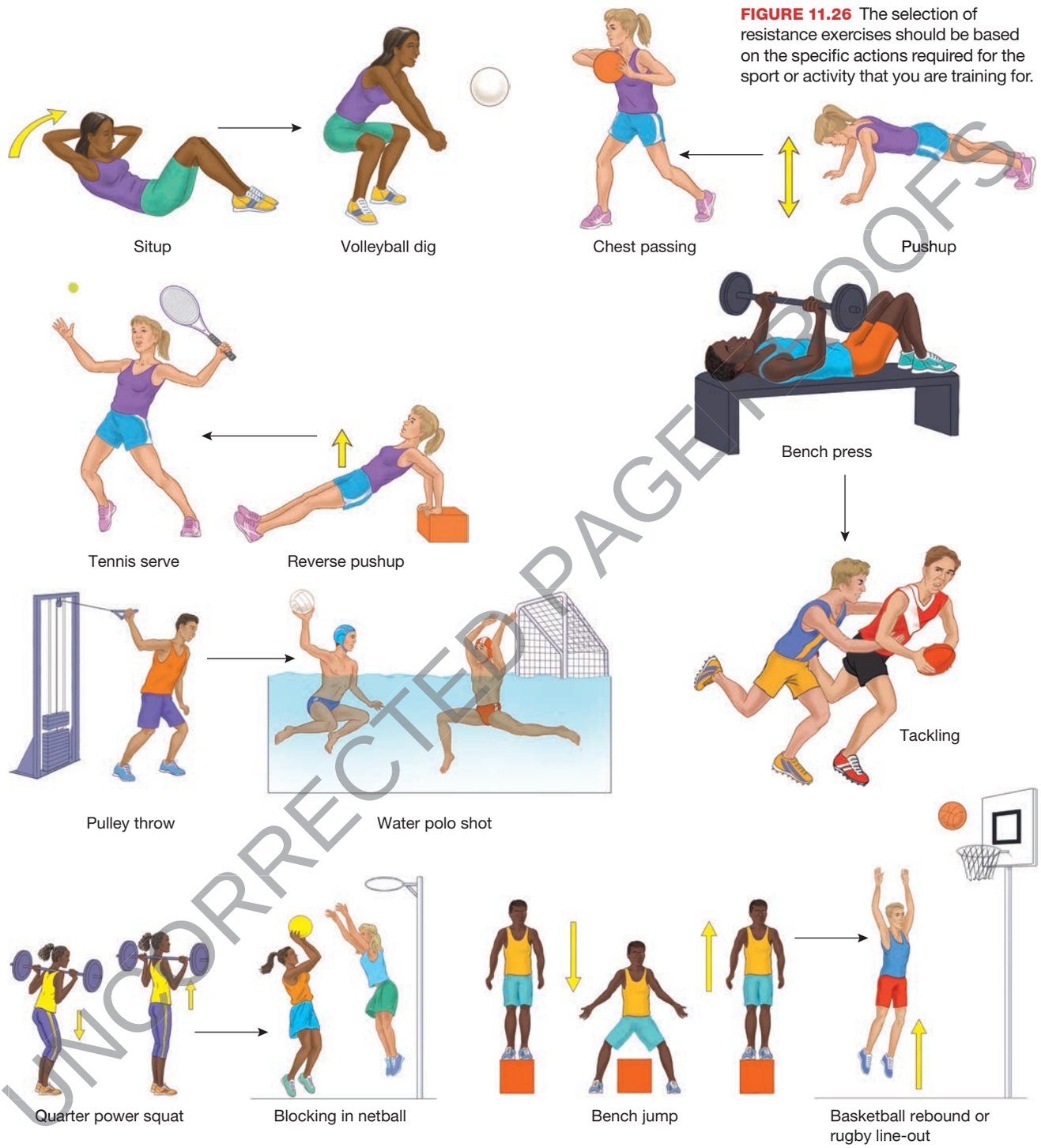

FIGURE 11.26 The selection of resistance exercises should be based on the specific actions required for the sport or activity that you are training for.

Some examples of this specificity are:

- bicep curls for handballs in Australian Rules football
- flies for tackling
- bench presses for netball or basketball chest passes
- quarter squats for basketball rebounds, long jump take-offs, sprint starts
- calf raises for running

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- tricep extensions for throwing
- sitting leg extensions for kicking in Australian Rules football
- various pulley resistance training for hockey long hits, groin strengthening work to avoid osteitis pubis and specific throwing movements.

Resistance training terminology

The language of resistance training is important for understanding resistance training and for applying it to your own training. Definitions of variables used in resistance training are provided in table 11.8.

TABLE 11.8 Definitions of variables in weight training

Variable	Definition
Repetition	A single effort or performance of an exercise
Repetition maximum (RM)	The heaviest load that can be successfully completed in a one contraction.
Set	The number of exercise repetitions performed in a sequence without rest
Resistance or load	The weight that must be moved in the exercise or effort
Contraction speed	The velocity at which a muscle contracts.

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Resistance training and training principles

The principles of training are most important in weight training:

- Specificity in relation to the relevant muscle groups is the first consideration of any weight-training program.
- Overload is applied using the variables outlined earlier. There are no set rules as to which variable is more appropriate because research and studies on the matter are inconclusive. The most important consideration is to use gradual overload, remembering that too little is much safer than too much.
- Frequency should be one to three times per week depending on other training methods being used, recovery strategies and level of desired performance.
- The duration of the program should be a minimum of six weeks to obtain significant gains.
- The exercises within the weight program should be ordered in a way that does not use the same muscle or muscle group twice in a row. Cycling of muscle or muscle groups is required to avoid excessive stress on the muscles and allow recovery.
- When devising a weight-training program, first decide the aim of your program — is it to develop muscular strength, muscular power or muscular endurance?

Only one component can be developed at one time. Once decided, ensure you develop the specific fitness component in the following order: muscular endurance, muscle size or hypertrophy, strength and finally power. In order to develop a strength or power weights program, weight training should be carried out in phases. This means that endurance must be developed in the muscle before you progress to the next phase.

There has been much discussion and difference of opinion on the most appropriate number of sets, weights and repetitions to maximise strength, power or muscular endurance. Traditionally, high weights and low repetitions equated to strength training, while higher repetitions and lower weights equated to muscular endurance training. There is also no doubt that a program designed for strength will indirectly help improve muscular endurance and power, and vice versa.

Table 11.9 outlines weight-training variables recommended by the American College of Sports Medicine for improving strength, power, endurance and hypertrophy of muscles.

TABLE 11.9 Muscular strength resistance training

Training level	Load %RM	Reps	Sets	Contraction speed	Rest/recovery	Frequency (days per week)
Novice	60–70%	8–12	1–3	Slow/ moderate	2–3 min heavy loads 1–2 min light loads	2–3
Intermediate	70–80%	6–10	2–6	Moderate	2–3 min heavy loads 1–2 min light loads	3–4
Advanced	80–100%	1–12	2–6	Slow to fast	2–3 min heavy loads 1–2 min light loads	4–6

Muscular power resistance training

Training level	Load %RM	Reps	Sets	Contraction speed	Rest/recovery	Frequency (days per week)
Novice	30–60%	3–6	1–3	Moderate	2–3 min heavy loads 1–2 min light loads	2–3
Intermediate	30–60%	3–6	1–3	Fast	2–3 min heavy loads 1–2 min light loads	3–4
Advanced	85–100%	1–6	3–6	Fast	2–3 min heavy loads 1–2 min light loads	4–5

Muscular endurance resistance training

Training level	Load %RM	Reps	Sets	Contraction speed	Rest/recovery	Frequency (days per week)
Novice	50–70%	10–15	1–3	Slow for moderate reps Moderate for high reps	1–2 min for high-rep sets	2–3
Intermediate	50–70%	10–15	1–3	Slow for moderate reps Moderate for high reps	1–2 min for high-rep sets	3–4
Advanced	30–80%	10–25+	Multiple	Slow for moderate reps Moderate for high reps	>1 min for 10–15 reps	4–6

Muscular hypertrophy resistance training

Training level	Load %RM	Reps	Sets	Contraction speed	Rest/recovery	Frequency (days per week)
Novice	70–80%	8–12	1–3	Slow to moderate	1–2 min	2–3
Intermediate	70–80%	8–12	1–3	Slow to moderate	1–2 min	4
Advanced	70–100%	1–12	3–6	Slow, moderate, fast	2–3 min for heavy loads 1–2 min for medium loads	4–6

Source: Adapted from the American College of Sports Medicine, 2013

Summary of differentiating factors between the types of resistance training:

Muscular strength — high load (%RM) and low volume (reps)
Muscular power— moderate load (%RM) with fast contraction speed
Muscular endurance — low load (%RM) and high volume (reps)
Muscular hypertrophy — moderate relative loads (%RM) and high volume (reps)

Guidelines for undertaking resistance training safely and effectively

When developing a resistance training program, it is necessary to consider the following general guidelines.

BASIC GUIDELINES FOR WEIGHT TRAINING

- Always properly warm-up and cool-down the muscles that are used in each resistance training session.
- Make sure that you concentrate on performing each exercise using correct body posture and complete each range of movement smoothly so as to avoid injury and prevent the development of bad habits.
- Stay in control of the movement and work at a good tempo.
- It is best to start a program with lower weights and higher repetitions.
- Think about your breathing technique. Exhale as you work against the resistance and inhale as you are releasing the resistance.
- Try to work different muscle groups with sequential exercises.
- Gradually increase the load by between 2% and 10% when you can comfortably perform the current workload over two consecutive training sessions, so as to avoid overtraining. Remember that you should be able to do all the repetitions using good form and the muscles should feel tired by the last two repetitions.
- Train the larger muscle groups first, progressively working towards training the smaller muscle groups in one session and ensure exercises targeting core strength are completed towards the end of the session.
- Ensure adequate rest and recovery of the muscles between training sessions. Strength training causes tiny tears in muscle tissue which is important for achieving anabolic adaptations during recovery. Your muscles should have at least 48 hours to recover between each strength training session.
- Use a spotter for free weight activities such as squats and bench presses.

TEST your understanding

1. Define resistance training.
2. Outline some of the different types of resistance training.
3. Describe isoinertial resistance training.

APPLY your understanding

4. List some specific sporting examples of movements that would benefit from isometric resistance training. Justify your choices.
5. Explain the value of isokinetic resistance training machines.
6. Explain why core stability training is important.
7. Discuss the benefit of incorporating eccentric overload training into a resistance program.
8. With reference to a sport or activity of your choice, explain whether you would select to train for strength, power or endurance. Justify your selection with examples.
9. **Practical activity: resistance training session**
   Design a resistance training session that is appropriate for a particular sport or activity and guide your class group through the session. Make sure that your session includes the appropriate variables that are required to train strength, power or endurance and that you target your session at a level that is suitable for all participants.

EXAM practice

10 **(ACHPER Trial Exam 2014, question 5)**

Research has proven that resistance training is an effective training method to use in order to increase muscular strength. Complete the table below, to show an appropriate overload for a leg press exercise in a resistance training program for an elite athlete.

Exercise	Repetition Maximum (RM)	Number of repetitions	Number of sets	Duration of rest
Leg press	80% RM	5	6	2 minutes
Overload			6	

1 mark

11 **(ACHPER Trial Exam 2014, question 5)**

The following program is being performed by a beginner trying to improve the muscular power of their legs.

Exercise	1RM Max (kgs)	Weight to lift	Sets	Reps	Rest	Speed of contraction
Squat	50	15–30	3	4	1 min	As fast as possible
Leg press	50	25	6	4	2 mins	As fast as possible
Bent knee deadlifts	30	9–18	3	6	3 mins	As fast as possible
Leg extension	25	20	2	8	2 mins	As fast as possible
Leg curl	25	15	2	6	2 mins	As fast as possible

(a) Outline two errors in the above program. **2 marks**

(b) For each error identified in part (a), suggest a modification that will enable the exercise to meet the intended aim of the program. **2 marks**

11.7 Flexibility and plyometrics

KEY CONCEPT Flexibility is an essential component of fitness in all active sports and plyometrics is an effective method to develop muscular power.

Flexibility

Flexibility refers to the ability of specific joints to move through the full range of motion.

Flexibility is specific to each joint; an individual can be high in flexibility in some joints and not so high in others. A very flexible person has a full range of motion for a given joint. Flexibility training is about improving the range of motion at the desired joints that are important for maximum performance in the designated activity.

For gains in flexibility, an athlete needs to undertake a stretching program three or four times per week for three weeks. If they stop training, their flexibility reverses at about the rate of improvement. There is insufficient evidence from research about the role of stretching in preventing injury, however stretching does improve flexibility, posture and body awareness (proprioception), and also helps to relieve stress.

The ideal timing in which to include any stretching aimed at improvement is after any training or exercise session. Many studies have proven that the benefits of post-exercise stretching outweigh those of pre-exercise stretching in terms of developing flexibility.

Before any flexibility training, the participant should undertake a thorough and general aerobic warm-up to increase blood temperature and circulation and thus minimise injury and maximise the potential to improve performance. It is good practice to include flexibility training at the end of every training session, however flexibility training can also be the main focus of a session or program.

Methods of stretching that may be incorporated into a training program

There are a variety of recognised methods of stretching; some of these include:

- static (or passive)
- slow active
- proprioceptive neuromuscular facilitation (PNF)
- dynamic
- ballistic.
- myofascial release

Static (or passive) stretching

Static stretches involve holding the end point of a stretch for up to 30 seconds.

Static stretching is the safest and easiest method to practise. It involves a thorough, adequate and total body warm-up, then gradually stretching the muscle groups across a joint to the full range of motion and holding for 15–30 seconds (figure 11.28). This is also the most effective stretching method in a cool-down following the most exhaustive part of an exercise bout.

Hamstring stretch | Groin stretch | Shoulder stretch

FIGURE 11.27 Some commonly used passive stretches

Slow active stretching

Slow active stretching involves slowly moving the joints through the range of motion, relaxing the agonist and repeating the stretch. This type of stretching is common in aerobics classes and is considered low risk because it is controlled by internal rather than external forces.

PNF (proprioceptive neuromuscular facilitation) stretching

PNF stretching is considered to be 20 per cent more effective than other methods, if undertaken correctly. PNF involves the use of muscle isometric contraction before the stretch in an attempt to achieve maximum muscle relaxation.

If the muscle is first moved to isometrically contract against an immovable resistance, it develops a greater ability to stretch through its range of motion. These steps should be followed:

1. You thoroughly warm up first.
2. You move into the stretch position so that you feel the stretch sensation.
3. Your partner holds the limb in this stretched position.
4. You then push against your partner by isometrically contracting the antagonistic muscles for 6–10 seconds and then relax. During the contraction, your partner aims to resist any movement of the limb.
5. Your partner then moves the limb further into the stretch until you feel the stretch sensation. Hold for 10–15 seconds.
6. Repeat steps 4 and 5 three or four times before the stretch is released.

PNF stretches can also be undertaken individually, as shown in figure 11.29.

FIGURE 11.28 PNF stretches — individual and partnered

Dynamic stretching

Dynamic stretching consists of slow, controlled movements through the full range of motion. For example, controlled leg and arm swings that take you gently to the limits of your range of motion.

Where the event requires a dynamic movement, then it is appropriate and perhaps necessary to conduct dynamic stretching exercises. Start with the movement at half speed for a couple of repetitions and then gradually work up to full speed.

Dynamic stretching and mobility exercises could form part of the warm-up in a training session. The dynamic exercises you use should be similar to or the same as the movements you would experience in your sport or event. Current research suggests that the use of dynamic stretches is more appropriate than static ones for the warm-up.

Basic examples of dynamic stretching are seen when players warm up before a game. Their hitting, kicking, running and throwing is taking various and relevant body parts through the ranges of motion needed in the game.

Ballistic stretching

Ballistic stretching is a controversial, higher risk type of stretching because it involves moving through the range of motion using the momentum created rather than the muscle contraction. Only specifically conditioned athletes such as experienced dancers, high-level team players and gymnasts are recommended to use ballistic stretching. Ballistic stretching uses the momentum of a moving body or a limb in an attempt to force it beyond its normal range of motion.

A common example of ballistic stretching is bouncing down repeatedly to touch your toes. This type of stretching does not allow your muscles to adjust to, and relax in, the stretched position. It may instead cause them to tighten up by repeatedly activating the stretch reflex. However, if there are ballistic movements in the particular sport or activity that a person is training for, then it may be appropriate and even necessary to conduct ballistic stretching exercises as part of preparation.

The stretch reflex (also called the myotatic stretch reflex) attempts to resist the dynamic stretch's sudden change in muscle length by calling on the stretched muscle to contract. It is the body's attempt to prevent the suddenly stretched muscle from tearing. The more sudden the change in muscle length, the stronger the muscle's answering contractions will be.

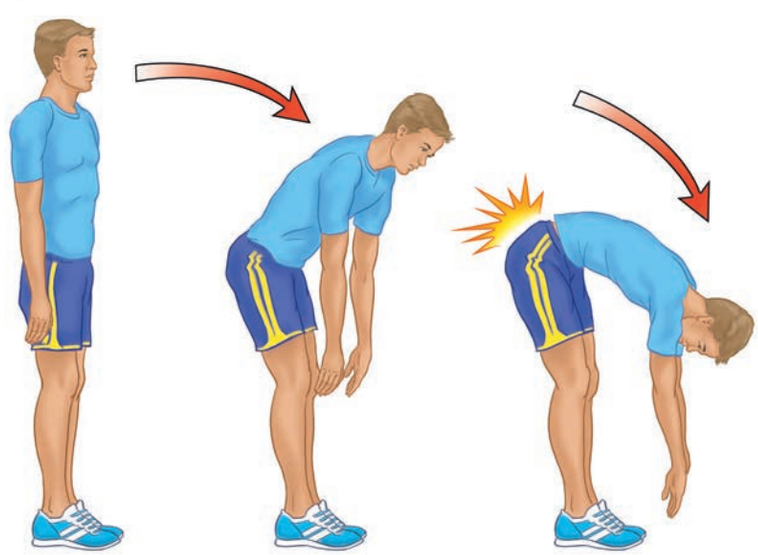

FIGURE 11.29 Inexperienced performance of ballistic stretching can result in severe lower back problems.

Myofascial release

Myofascial release is a technique that is used to apply pressure to tight areas of the **fascia** that underlies the muscle. This technique aims to relieve tension and improve the flexibility of the targeted joint. The most common method of myofascial release involves the use of a foam roller and the combination of gravity and body weight controls the pressure on the particular area. The technique reduces soft tissue tension, restoring normal muscle length and therefore providing an overall improvement of the muscle function.

Fascia is a densely woven connective tissue that covers and bonds internal sections of the body.

FIGURE 11.30 Myofascial release of the iliotibial band using a foam roller

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Plyometrics

Plyometrics is an excellent way for conditioned athletes to increase and develop their force production, velocity and power output.

It is also known as depth jumping or rebounding in which an eccentric contraction is immediately followed by a concentric contraction.

The eccentric stretching of the muscle prior to the rapid concentric contraction allows for a more forceful contraction, recruiting more motor units than if no pre-stretch occurred. During the eccentric phase, **potential energy** is stored in the elasticity of the muscle and then released at the start of the concentric phase of contraction.

Think of an elastic band: the elastic proteins of a muscle fibre act in a similar manner as an elastic band when it is stretched and released. There are three phases of plyometrics:

1. The eccentric pre-stretch phase — during this phase, the muscles are stretched rapidly, which activates the **stretch reflex** causing a powerful concentric contraction to protect the muscle from overstretching.
2. The amortisation phase — the very short phase between the eccentric and concentric contraction.
3. The concentric shortening phase — during this phase, the muscles contract forcefully with assistance from the stored potential energy (elastic energy) gained from the eccentric and amortisation phases.

Plyometric actions occur in many sporting activities. Leg muscles in each running stride are actually performing plyometrics as each leg lands on the running surface.

Plyometrics involves the use of the stretch-shortening muscle cycle to produce powerful and explosive movements.

Potential energy is the capacity of the muscle to do work based upon its position. This happens in the eccentric phase of contraction. The greater the stretch, the greater the capacity of the concentric muscle contraction.

The **stretch reflex** occurs when an impulse is immediately sent to the spinal cord for a muscle to contract when it is stretched in order to prevent overstretching.

A baseball player, must first swing the bat back, stretching the muscle, before contracting the muscle to hit the ball. If the player stops in the back swing or simply swings at the ball without a back swing, they either lose power or do not even generate it.

Because plyometric exercises can create so much muscular power, there is understandable concern about their safety and appropriateness. They place considerable pressures on both the body and joints and are not recommended for persons of poor or average fitness abilities. Table 11.10 outlines the different stress levels and recovery times for various plyometric exercises.

An athlete's number of training years is important. Those with little foundation training should start with the low-stress or low-impact activities, which have low demand on the nervous system and low motor complexity.

TABLE 11.10 The impact of varying intensity plyometric training programs

Rating	Recovery time	Example
1 = very low stress	Recovery very rapid	Jump rope or ankle bounces or other similar low-amplitude jumps
2 = low stress	Recovery rapid; one day required	Tuck jump or other similar activity in place of jumps
3 = moderate stress	One to two days required	Stair jumps or other similar short jumps
4 = high stress	Recovery slow; two days required	Hops or bounds for distance or other similar long jumps
5 = very high stress	Recovery very slow; three days required Highest nervous system demand	Depth jumps or other similar shock-type jumps

Source: Gambetta V 1998, 'Plyometrics: myths and misconceptions', *Sport Coach*, summer, p. 7.

Plyometric training guidelines

1. An adequate warm-up must be performed, consisting of general aerobic activities progressively increasing in intensity and including dynamic flexibility.
2. The development of a good strength base should precede plyometric training.
3. Begin with low to moderate level plyometric exercises and progress to higher levels when sufficient strength and power have been developed.
3. Plyometric exercises should be performed in a controlled manner using good postural technique.
4. Footwear that has good ankle and foot support is recommended.
5. Plyometric exercises should be undertaken on shock-absorbing surfaces.
6. Plyometric exercises should be undertaken early in a training session so that the exercises aren't being performed when the person is fatigued.
7. There should be at least 48 hours recovery between each plyometric session and a maximum of two sessions per week for beginners.

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Low impact vs. high impact plyometric exercises

Examples of low-stress or low-impact plyometric drills are:

- skipping with and without a rope
- doing low hops, steps and jumps
- throwing light objects such as cricket balls and frisbees
- throwing a light (2.5 kilogram) medicine ball
- jumping 360 degrees.

The height for low-impact exercises is 25 centimetres or less, and the beginner should start with repetitions of 10 × 1–5 sets. The appropriate rest and recovery time between sets is 3 minutes.

Examples of high-stress or high-impact plyometric drills are:

- bounding with alternate legs
- bounding with both legs
- speed hopping on a single leg

- doing clap pushups
- jumping over, on and from benches that are 35 centimetres high
- triple jumping
- throwing a heavy medicine ball (above 4 kilograms).

The height for high-impact exercises is 35 centimetres and above, and the athlete should perform repetitions of 10–25 × 1–5 sets. The appropriate rest and recovery time between sets is 10 minutes.

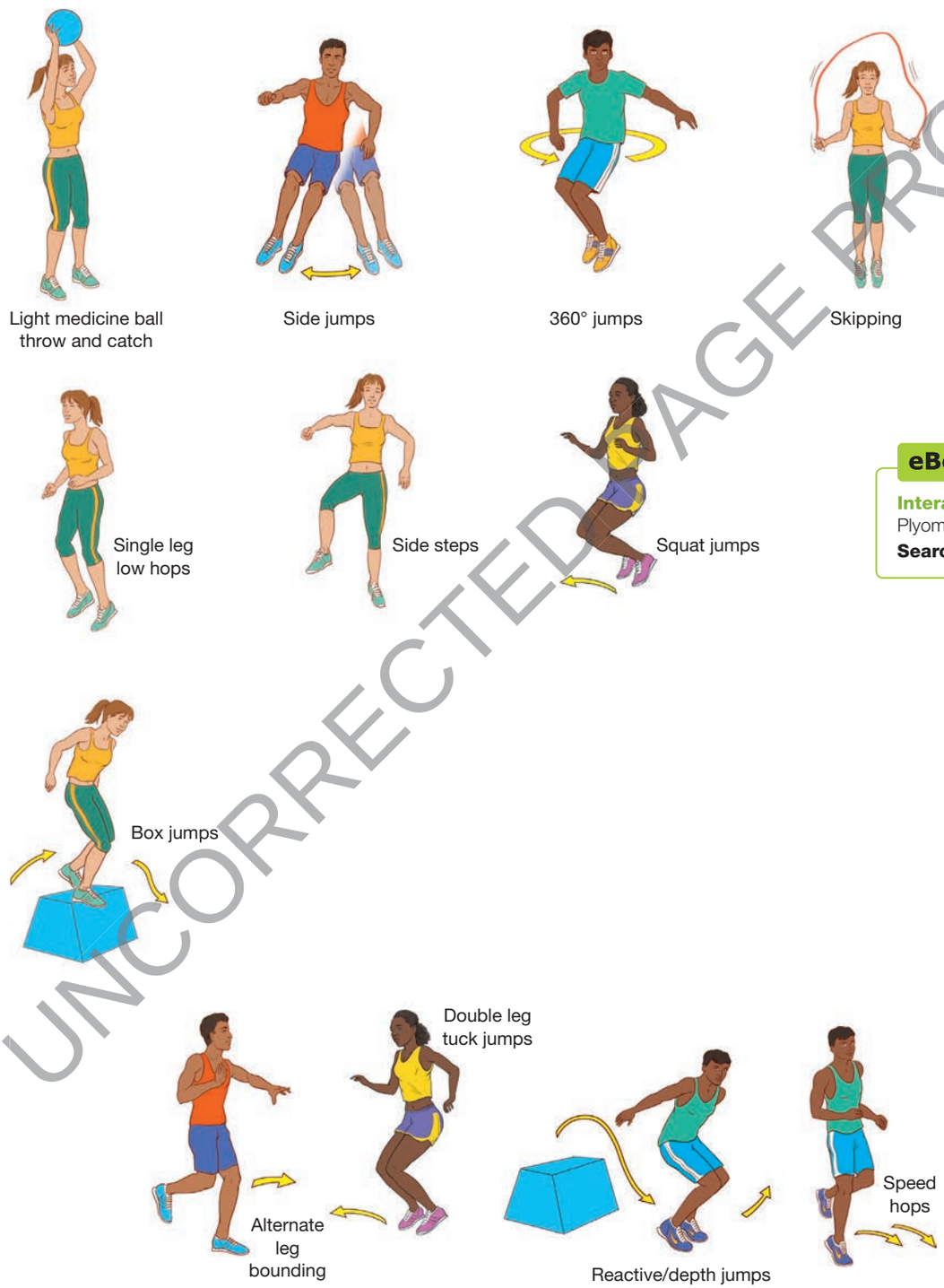

FIGURE 11.31 Plyometric excercises

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Interactivity
Plyometric exercises
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TEST your understanding

1. Define flexibility.
2. What must be done before any form of flexibility training is carried out?
3. Define static stretching.
4. Define PNF stretching. What does PNF stand for?
5. List some examples of dynamic stretching movements seen before an a sport of a choice.
6. List some activities where ballistic stretching would be expected and acceptable.
7. Explain the stretch reflex and how it applies to plyometrics.
8. Discuss what is meant by the term *myofascial release*.

APPLY your understanding

9. Explain the differences between static and slow active stretching.
10. Describe some PNF stretches that would increase the flexibility of the following muscle groups:
    (a) pectorals
    (b) hamstrings
    (c) quadriceps
    (d) triceps
    (e) calves.
11. Discuss the importance of three recommended guidelines when undertaking plyometric training.
12. List and justify five plyometric exercises for a sport of your choice.
13. **Practical activity: flexibility**
    (a) Carefully complete a flexibility test, prior to and after an aerobic warm-up.
    (b) What were the results?
    (c) Explain the reasons for the results obtained.
    (d) Design and implement a flexibility session using static and PNF stretches.
14. **Practical activity: plyometric training session**
    (a) Design a safe and effective training session for your class to undertake. Your training session template needs to include an appropriate warm-up, four plyometric exercises that are suitable for your class group (2 upper body and 2 lower body) to perform and an adequate cool-down.
    (b) Provide a justification of your selection of plyometric activities.

EXAM practice

15 **(ACHPER Trial Exam 2011, question 11)**

Sally Pearson is a track and field athlete who competed in three events at the 2010 Delhi Commonwealth Games: the 100 metre hurdles, 100 metre sprint, and she was a late inclusion in the 4 x 400 metre relay. Sally won gold in the 100 metre hurdles event. Plyometrics is a training method that Sally regularly uses to improve her skill in the hurdle event.

(a) Describe one plyometrics exercise that Pearson may use to improve her performance in the 100 metre hurdles. **1 mark**

(b) Plyometrics training is used no more than two to three times per week. Outline a likely reason as to why plyometrics would be utilised less frequently. **2 marks**

(c) Other than plyometrics training, identify one suitable training method Pearson could use when training for the 100 metre hurdles. **1 mark**

(d) Pearson was controversially included in the team for the final of the women's 4 x 400 metre relay, an event she had not trained for, and collapsed after running her leg of the race. The Australian team finished in fifth place. Outline a training method that Pearson might have undertaken if she was training for the 400 metre event that would be different to her hurdles training. **2 marks**

(e) Outline two training principles a coach should ensure his athletes are aware of during their 'off season'.
Training principle 1 _____
Training principle 2 _____
2 marks

16 **(ACHPER Trial Exam 2005, question 13)**

The coach of the Australian rugby team devotes approximately 30–45 minutes of each training session to 'flexibility work'.

(a) Explain how slow active stretching potentially delivers greater increases to flexibility than static stretching does. **2 marks**

(b) PNF stretching includes isometric muscle contractions. Briefly discuss how isometric contractions are different from isokinetic contractions. **2 marks**

11.8 Circuit and fartlek training

KEY CONCEPT Both circuit training and fartlek training can be designed to train the aerobic and anaerobic energy systems.

Circuit training

Circuit training comprises working at a variety of activity stations in sequence, training a number of fitness components at once.

Circuit training can have 5 to 15 stations that focus on specific components of fitness from the selected activity. An athlete can plan to train any of the fitness components in a circuit training session. Circuit training is a very versatile training method as it can be planned with minimal use of equipment, be performed indoors or outdoors and target a variety of aspects that are relevant to the activity or sport for which a person is training.

In circuit training the athlete completes one set of exercises and then moves on to the next. When the athlete has completed each exercise station once, they have completed one lap of the circuit.

Exercise stations should be arranged so that body parts are cycled or distributed. One body part should not be repeated twice in a row. For example, a leg station such as stepups could be followed by situps. This allows for specific muscle group recovery to take place.

Circuits also allow for specific skill drills to be included as exercise stations. In this way both the physical and skill requirements of the sport are being specifically trained at the one time. For example, a field-hockey player could include push passes against a rebound wall or to a team mate as an exercise station.

The circuit can also be designed to focus on general aerobic fitness. This type of training allows a large number of participants to work in a confined area with minimal equipment, so it is inexpensive and efficient. Each training session should be designed to reflect the energy systems, muscle groups, fitness components and fatiguing factors of the game or activity.

Types of circuit training

Fixed time

- Each person completes as many repetitions of an exercise as they can at each station in an allocated time (30–60 seconds).
- W:R ratios are designed in relation to the requirements of the activity or sport.
- Easy to administer to large groups as everyone moves from station to station at the same time.

Fixed load

- Each person completes a predetermined number of repetitions at each station.
- Individual strengths and weaknesses are not taken into account.
- Each person will complete each station at different times so quite impractical for large groups.

Individual load

- Each person will have undertaken a pre-test to determine the maximum number of repetitions that can be performed in 60 seconds at each station and then work at a percentage of these repetitions.
- Each person will be completing different repetitions so it is likely that some wait time will be experienced between stations.
- Individualised to each person's strengths and weaknesses.

Overload implementation in circuit training can be done by:

- increasing the repetitions
- increasing the number of circuits
- increasing the weights
- changing the length and nature of their recovery periods.
- For fixed interval circuits the athlete could also lengthen the work period.

An example of an individual circuit record sheet working at 50% of 1 minute repetitions is shown in table 11.11.

TABLE 11.11 Example of an individual circuit record sheet

Stations	Score for 1 minute	Half score	Time and date	Time and date	Time and date
Skipping	50	25			
Situps	60	30			
Pushups	50	25			
Agility run	6	3			
Basketball throw	20	10			
Stepups	50	25			
Medicine ball throw	20	10			
Ladder climb	6	3			
Shuttle run	10	5			
Initial time (three circuits)		21 minutes			
Target time		14 minutes			

There are any number of potential circuit training exercises that can be used in a particular training session, however the principle of specificity means that the exercises selected should train particular aspects required in the sport or activity that the person is training for.

Fartlek training

Fartlek training works both the aerobic and anaerobic energy systems by interspersing continuous low/ medium intensity efforts with high intensity efforts.

Fartlek training, a variation of continuous training, involves changes of intensity throughout the training sessions. These changes of intensity can be simply an increase in pace or running up a hill, and involve the addition of the anaerobic glycolysis energy system to help produce the increased amount of ATP needed for the increased intensity. As a result, it stimulates the interplay between the aerobic and anaerobic energy systems used in individual sports (such as sprinting to gain a better position within the field of runners), and in team games (when involved in a sprint to the ball, followed by jogging to a new position on the field).

Team game players need to build into a fartlek session all the variations of effort and directions of effort that are evident in their activity analysis.

Individuals or groups at varying fitness levels can undertake fartlek training, which can be completed in a relatively confined space such as an oval or around local streets.

Fartlek is mainly used by runners, but the concept is equally useful for swimming, cycling, rowing and skiing basically any sport where a combination of aerobic and anaerobic energy is important. Ways to overload using Fartlek training:

- increase the frequency of the high intensity efforts
- increase the duration of the high intensity efforts
- increase the overall distance covered
- include more hills and variety in terrain
- shorten the time to cover the same distance.

FIGURE 11.32 Elite track athletics runners use various forms of fartlek training to optimise their tactical surges during races.

TEST your understanding

1. Define circuit training.
2. Explain the major benefit of circuit training.
3. Name the three methods of designing a circuit training session.
4. Define fartlek training.
5. Identify which sports are best suited to fartlek training.

APPLY your understanding

6. Discuss which of the five main principles of training is most important when designing a circuit training program. Why?
7. List five exercises that would be appropriate to be included in a circuit training session designed for each of these sports:
   (a) netball
   (b) soccer
   (c) Australian Rules football
   (d) water polo
   (e) rowing
   (f) volleyball.
8. Justify your selection of exercises in question 7.
9. Explain how you could progressively overload a fartlek training program.
10. **Practical activity: design a circuit training program**
    Choose one of the following team sports:
    - netball
    - soccer
    - Australian Rules football
    - lacrosse
    - rugby
    - volleyball
    - hockey.

    (a) Design a circuit that has eight relevant fitness stations.
    (b) Have your class complete the circuit in either of the two fixed types of circuit training.
    (c) Complete the circuit using both the fixed and individual load methods.
11. **Practical activity: design a fartlek training session**
    Design a fartlek training session, for your class group to participate in. Try designing one that uses the space of a basketball court. Be sure to be creative and include different intensities and movements relevant to a sport of your choice. Draw your session as a map in order to explain it to your class group easily.

KEY SKILLS TRAINING PROGRAM: PRINCIPLES AND METHODS

- **yellow** identify the action word
- **pink** key terminology
- **blue** key concepts
- **light grey** marks/marking scheme

KEY SKILLS

- Design a training program that demonstrates the correct application of training principles and methods to enhance and/or maintain fitness components
- Evaluate and critique the effectiveness of different training programs

UNDERSTANDING THE KEY SKILLS

To address these key skills, it is important to remember the following:

- Be able to select the most appropriate training methods to train the relevant fitness components for a variety of sports
- Know how to correctly apply each of the training principles to each type of training method
- Be able to identify the aspects of a training program that make it successful
- Know how to use different monitoring strategies to assess the effectiveness of a training program

PRACTICE QUESTION

1 **(adapted from ACHPER Trial Exam 2015, question 12)**

Bobby is an Australian nationally ranked 16-year-old male swimmer in the 400m freestyle event. His personal best time is 3 minutes 53 seconds. Two training methods that Bobby participates in as part of his training program are long-interval training and intermediate-interval training. With specific reference to lactate tolerance and the lactate inflection point, **justify** the inclusion of each of these training methods in Bobby's training program.

8 marks

SAMPLE RESPONSE

Intermediate-interval training would require Bobby to train with a W:R ratio of 1:3, therefore targets the use of the anaerobic glycolysis energy system, which produces lactic acid as a by-product. Training under these physiological conditions results in the chronic adaptation of improving lactic acid buffering capacity and also improves lactate tolerance, which is the ability to withstand larger amounts of lactic acid in the muscles. This will enable Bobby to increase his ability to work maximum intensity by increasing the capacity of the anaerobic energy systems usage when racing to the wall in the last 100m of the event.

Long-interval training would require Bobby to train with a W:R ratio of 1:1 or less and therefore target the aerobic energy system with a chronic adaptation of increasing mitochondrial size and density. These adaptations increase the lactate inflection point (LIP), which is the highest intensity point where there remains a balance between lactate accumulation and removal or highest steady state exercise intensity. Lactic acid breakdown results in hydrogen ions being produced and when an athlete exercises at an intensity above their lactate inflection point (LIP), fatigue results. The increased mitochondrial size and density allows for the aerobic energy system to meet the demands at higher intensities before the anaerobic glycolysis system is required to increase its contribution and therefore less lactic acid is being produced at a higher intensity. Bobby is able to work at higher intensity for longer when pacing in the middle of the race and produce a faster time overall for his freestyle event.

STRATEGIES TO DECODE THE QUESTION

- **Identify the action words:** **Justify** — explain why the option you chose is the **best** option
- **Key terminology:** Long-interval training and medium-interval training — outline the characteristics/components of long- and medium-interval training lactate tolerance and lactate inflection point — explain what is meant by lactate tolerance and lactate inflection point
- **Key concepts:** inclusion of each of these training methods in Bobby's training program — discuss the physiological benefits that each training method has in relation to improving performance
- **Marking scheme:** *8 marks* — always check marking scheme for the depth of response required, linking to key information highlighted in the question

HOW THE MARKS ARE AWARDED

- **1 mark each (2 marks)** for describing long- and medium-interval training and the energy systems that they train
- **1 mark each (2 marks)** for defining lactate tolerance and lactate inflection point
- **1 mark** for explaining how medium-interval training method improves lactate tolerance
- **1 mark** for explaining how long-interval training method improves lactate inflection point
- **1 mark each (2 marks)** for providing examples of how increased lactate tolerance and LIP would benefit Bobby's performance

CHAPTER REVIEW TRAINING PROGRAM: PRINCIPLES AND METHODS

CHAPTER SUMMARY

- Training principles refer to the rules or guidelines that ensure the training session is relevant to the initial aim. The five primary training principles are as follows.
  1. Specificity: a replication of the requirements of an activity in the training for that activity.
  2. Intensity: the level of demand of the work rate on the working muscle, usually measured as a percentage of maximum heart rate.
  3. Time: the length of the training program or session.
  4. Frequency: the number of sessions trained per week with appropriate periods of rest.
  5. Progressive overload: the application of increased physical workload in training so the human body can adapt to higher levels of stress or workload.
- Other training principles for the success of a training program include:
  - variety, where the range of different activities, the order of exercises and the venues can all improve player motivation
  - diminishing returns, where the rate and amount of improvement reduce as fitness levels increase
  - de-training, where the loss of fitness increases as the period of time without training becomes greater
  - maintenance, where current levels of fitness can be maintained with less frequency than that required to improve fitness (although the intensity levels must remain the same)
  - individuality, where the rate and amount of improvement varies from one individual to the next.
  - Overtraining is when there is a long-term decline in performance and physical functioning. The ability of the body to continue to adapt to the training load is compromised when overtraining symptoms occur.
- Training methods are specific activities or groups of activities that cause an improvement in particular fitness components and energy systems.
  - Continuous training: slow-distance activities, such as running, that are designed to improve aerobic fitness.
  - Interval training: periods of work followed by periods of rest and recovery. This method is excellent for team games and individual activities where the interplay and recovery of energy systems are important.
  - Resistance (weight) training: movement of a load by a particular muscle group or groups to improve strength, power endurance or hypertrophy. There are different forms of resistance training.
  - Flexibility training: the stretching of individual muscle groups to allow an increase in the range of motion for the joint. There are different types of flexibility training — PNF, static, slow active, ballistic and myofascial release.
  - Plyometrics: an explosive movement, such as skipping, that results from lengthening then shortening the muscle. It creates an increase in power.
  - Circuit training: a sequence of activities that are specific to the fitness component and energy system requirements of an activity or sport. It allows the athlete to train several fitness components and energy systems at the one time, and can be done by large numbers of people in a confined space.
  - Fartlek training: slow-distance activities, such as cycling, that are interspersed with higher-intensity efforts, such as sprints, and three-quarter pace efforts. This method is designed to improve the aerobic system and, to a lesser extent, the anaerobic system. It is an excellent method for activities such as team sports where the interplay between energy systems is important.

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EXAM PREPARATION

MULTIPLE CHOICE QUESTIONS

1 **(ACHPER Trial Exam 2015, question 12)**

Identify the correct training prescription to develop the specified fitness component.

Fitness componet	Load (% of 1 repetition maximum)	Repetitions	Sets
A. Strength	40	4	3
B. Power	40	4	3
C. Endurance	80	15	3
D. Hypertrophy	40	8	3

2 **(ACHPER Trial Exam 2014, question 6)**

Georgina has been a member of the school's cross-country team, which has been training three times per week, for the past four months. During a Physical Education class, Georgina reached level 7.2 in the 20-metre shuttle run test while her friend, Paige, reached level 6.1. Paige has never been involved in running and was invited to participate in cross-country training. Three months later, they did a post-test where Georgina reached 7.5, but she was surprised that Paige reached 7.8 after only three months of training.

The training principle that best explains this situation is

(A) reversibility.
(B) detraining.
(C) law of diminishing returns.
(D) overload.

3 **(ACHPER Trial Exam 2013, question 15)**

The following table displays an example of a training day for a 1500-metre runner.

Sets	Repetitions × Distance	Work period	Rest period
1	5 × 400 metres	80 seconds	Slow jog 90 seconds
2	7 × 600 metres	130 seconds	Slow jog 120 seconds

The training method utilised is

(A) intermediate interval.
(B) long interval.
(C) fartlek.
(D) continuous.

4 **(ACHPER Trial Exam 2012, question 14)**

Which of the following is **not** a correct way of overloading an interval training session?

(A) Increasing the number of repetitions
(B) Increasing the number of sets
(C) Increasing the recovery time
(D) Increasing the intensity of the work

5 **(ACHPER Trial Exam 2011, question 12)**

An elite male soccer player is trying to develop their lactate tolerance. They perform 6 × 100 metre sprints in 14 seconds. Which of the following recovery times would be the most appropriate after each repetition?

(A) 14 seconds
(B) 42 seconds
(C) 7 seconds
(D) 70 seconds

6 Myofacial release is a technique that

(A) is used to apply pressure to tight areas of the fascia.
(B) aims to relieve tension and improve the flexibility of the targeted joint.
(C) most commonly performed with the use of a foam roller.
(D) All of the above

7 The most important training principle in terms of fitness gains is
(A) reversibility.
(B) intensity.
(C) time.
(D) type.

8 Chronic fatigue lack of motivation towards a training program could be attributed to
(A) detraining.
(B) overtraining.
(C) variety.
(D) maintenance.

9 As athletes approach their fitness potential, the rate of fitness improvement decreases. This is
(A) caused by residual fatigue from previous training sessions.
(B) known as the law of diminishing returns.
(C) the consequence of an inappropriate training program.
(D) the result of too much variety in the training program.

10 **(ACHPER Trial Exam 2010, question 13)**

The following table shows four different resistance training programs.

	% Repetition maximum	Repetition range	Sets	Repetition speed	Rest between sets
Program A	40–60	10–15	3	Slow to moderate	1 minute
Program B	80	15–25	3	Slow to moderate	2–3 minutes
Program C	40–60	15–25	3	As fast as possible	1 minute
Program D	20	10–15	3	Slow to moderate	1 minute

The program that is best suited to improving muscular endurance for a beginner is
(A) Program A.
(B) Program B.
(C) Program C.
(D) Program D.

TRIAL EXAM QUESTIONS

Question 1 **(ACHPER Trial Exam 2014, question 4)**

Melissa is a Centre player for her secondary school netball team. The following data about Melissa were collected by her coach from the first quarter of a netball match. The match consisted of 4 × 10 minute quarters.

Work to Rest Ratio

Work/Rest Periods	Time (seconds)
Shortest work period	0.61
Longest work period	11.09
Shortest rest period	1.37
Longest rest period	31.21

	Work (seconds)	Rest (seconds)
Total	186.99	444.6
	1	2.378
Ratio (approx.)	1	2

Skills and their Frequency

Skill	Frequency
Chest Pass	9
Overhead pass	15
Catch	18
Jump	13
Guard	8
Defend	13
Leap Forwards	15
Leap Sideways	7
Change of direction	55
Centre pass	5

Locomotor Patterns

Loco-motion	Inten-sity	0-5 metres	6-10 metres	11-15 metres	16+ metres	Total (count)	Distance Metres	% Total	Average Metres
Walk	Low	12	7	3	2	24	111	26	4.6
Jog	Low-Medium	12	7	1	1	21	147	35	7.0
Sprint	High	11	9	1	0	21	127	30	4.8
Shuffle	Very High	18	4	0	0	22	36	9	1.6
Totals		53	27	5	3		421	100%	

a. Data was collected by the coach to ensure accurate application of which training principle? **1 mark**

b. Using the data provided, explain why a coach may consider including plyometrics training into a program for Melissa. **2 marks**

c. Describe or draw **one** specific plyometrics exercise that the coach could employ as part of Melissa's training program. **1 mark**

d. Using the data provided, complete the table below to provide a specific interval training session that the coach could use to improve Melissa's fitness to play as a netball Centre.

Sets	Repetitions	Time for each repetition	Recovery time between repetitions	Recovery time between sets
3	10	5 seconds		

2 marks

e. With reference to data, justify your choice of:

i. recovery time between repetitions

ii. recovery time between sets. **4 marks**

f. Discuss **one** reason why the frequency of the plyometrics sessions may differ from the frequency of the interval sessions that Melissa undertakes each week. **2 marks**

Question 2 **(adapted from ACHPER Trial Exam 2013, question 3)**

At the London 2012 Olympic Games, Sally Pearson won the 100m hurdles in a time of 12.35 seconds, while Yuliya Zaripova won the women's 3000m steeplechase in a time of 9 minutes and 6.72 seconds.

Both athletes would employ different training methods. Outline one training method likely to be undertaken by each athlete and justify your selection for each. **4 marks**

Question 3 **(ACHPER Trial Exam 2013, question 5)**

Georgina is a 35-year-old female who has decided to enter the Women's 5 km Fun Run in December. She attends gym regularly with a personal trainer who has advised her to begin the following continuous running training program 12 weeks before the event.

Week	Heart Rate Training zone	Session length	Sessions per week
1–3	130–135	30 minutes	3
4–6	135–145	30 minutes	3
7–9	145–150	35 minutes	3
10–12	150–155	40 minutes	4

a. Referring to the information above, outline two training principles that have been correctly applied in this training program. **2 marks**

b. Referring to the information above, identify one training principle that has been applied incorrectly and outline how this principle should be correctly applied. **2 marks**