INQUIRY QUESTION
Why do we use fitness tests and what needs to be taken into consideration when deciding on a specific fitness test?
Fitness tests need to be chosen carefully and administered in an appropriate way for results to be meaningful.

**KEY KNOWLEDGE**
- Assessment of fitness including:
  - the purpose of fitness testing including physiological, psychological and sociocultural perspectives
  - pre-participation health screening (PAR-Q)
  - informed consent
  - test aims and protocols
  - test reliability and validity
- Methods of at least two standardised, recognised tests for aerobic power, agility, anaerobic capacity, body composition, flexibility, muscular endurance, power and strength, and speed

**KEY SKILLS**
- Determine an appropriate fitness testing regime based on the physiological, psychological and sociocultural needs of the individual and the requirements of the activity
- Conduct a valid and reliable assessment of fitness using ethical protocols
- Perform, observe, analyse and report on practical laboratory exercises designed to assess fitness prior to designing a training program
- Justify the selection of fitness tests in relation to the physiological, psychological and sociocultural requirements of the test subject

**CHAPTER PREVIEW**

![Diagram of fitness testing process]

- Test reliability and validity
- Aims and protocols
- Assessment of fitness
- Purpose
- Pre
- During/in
- Post
- PAR-Q
- Informed consent
- Standardised recognised tests
  - Aerobic power, agility, anaerobic capacity, body composition, flexibility, muscular endurance, power, strength, speed
9.1 The types of fitness testing

KEY CONCEPT After activity analysis is completed, and you have identified the physiological requirements important to the activity, fitness testing can occur. It can be completed at multiple stages within a training program to ensure specificity, and ultimately, success.

Types of fitness testing

There are a number of different tests that can be used to assess fitness. These are often chosen based on the needs of the participant/s. For a test to be accurate, it needs to be completed free from error. This is very difficult to do. Even with specialised equipment, the equipment needs to be calibrated to each participant and for every test for maximal accuracy. This can be time-consuming and expensive.

Sometimes accuracy is not as important as practicality; for example, a local club coach may need to test a large number of players to motivate them at the beginning of the season. In this instance, practicality will be more important than accuracy.

In-laboratory tests

In-laboratory tests are those tests conducted under clinical laboratory conditions. They are the preferred means of assessing fitness components (especially for elite participants) because they often provide the most accurate indication of functional abilities. However, laboratory tests often require the use of expensive and sophisticated equipment, controlled environments, qualified personnel and take considerable time to complete, which can limit their accessibility and therefore their use. An example of such a state-of-the-art fitness testing program is the annual AFL draft selection camp at the Australian Institute of Sport (AIS) in Canberra. This testing has also been used to identify potential participants for the women's AFL draft.

FIGURE 9.1 The AFL uses laboratory testing to get reliable and accurate results to identify potential draftees.
Field tests
The alternative to laboratory testing is a carefully chosen battery of easily administered field tests, using readily available and inexpensive equipment. Such tests, although not as precise as laboratory tests, can provide estimates or predictions of fitness levels. They also allow simultaneous testing of large groups. Field tests are the type of fitness test that you will most often use in your Physical Education classes. Most fitness testing completed in a senior Physical Education class will be field tests where students undertake their own fitness testing under the observation of a class mate.

Direct tests
Direct tests are considered a very accurate measure of fitness. Direct tests are those that provide an immediate measure of the fitness component. The best example of a direct test is a VO₂ max. test, where the test gives the VO₂ value in L/min.

Indirect tests
Unlike direct tests, indirect tests provide a result that can then allow an estimation or prediction to occur, generally using normative data, in order to determine the measure of the fitness component. These tests are less accurate as they are compared to norms and are not individualised; however, they are far more practical, especially with large groups. Most field tests are indirect tests. An example of an indirect test is the multi-stage fitness test, where the level achieved can be used to predict a VO₂ max. value.

Maximal tests
While most tests require the subject to contribute their ‘best’ efforts, maximal tests are those that require subjects to work until exhaustion. This is generally associated with aerobic power tests. The best example of a maximal test is the VO₂ max. test. Maximal (or exhaustive) tests provide the most accurate means of determining maximum oxygen uptake.

VO₂ max. testing
VO₂ max. tests (treadmill, bicycle ergometer and rowing ergometer) are direct maximal tests.

Participants work to exhaustion by progressively increasing their workload on a treadmill, bicycle ergometer, rowing ergometer or other sport-specific ergometer. The workload on a treadmill, for example, can be altered by increasing both the speed and incline.

The individual is attached via a mouthpiece to a device and computer that continuously collect and analyse the expired air and calculate the amount of oxygen used. The test continues until the individual’s oxygen consumption reaches a plateau or they indicate that they are unable to continue (usually the latter).

Results of VO₂ max. can be given in absolute or relative forms. An absolute figure provides L/min whereas a relative figure is given in ml/kg/min. A relative figure allows better comparison between participants as it takes into account the participant’s weight.

Submaximal testing
Submaximal tests measure a subject’s efforts at certain intensity levels, below maximal, and then predict maximal capacity. Like maximal testing, this term is generally only used for aerobic power tests. Given the need for sophisticated and expensive equipment and other constraints of the maximal laboratory tests, a number of submaximal tests have been developed to provide a predictive value for maximum
9.1 The types of fitness testing

oxygen uptake. The individual works to a preset submaximal level and the results are used to estimate this value.

Submaximal tests to measure aerobic power use either physiological markers that highly correlate with maximum oxygen uptake (e.g. the heart rate response to submaximal exercise) or other measures of endurance performance (e.g. the distance run in a set time). Several cycle ergometer and step tests use heart rate responses, either during or after the exercise, as the basis for predicting maximum oxygen uptake. Such tests are based on the linear relationship between heart rate and oxygen uptake. A similar relationship exists between exercise intensity and oxygen uptake (see chapter 6).

It is important that students are aware of types of recognised standardised tests for aerobic power, agility, anaerobic capacity, body composition, flexibility, muscular endurance, power and strength, and speed.

**Standardised tests** follow clear protocols that allow them to be confidently and successfully repeated.

**TEST your understanding**
1. Using an example, outline what a laboratory fitness test is.
2. Using an example, outline what a field fitness test is.
3. Give examples of a maximal and a submaximal test for aerobic power.
4. Discuss the differences between a direct and indirect test, using examples.
5. Describe the most accurate form of testing.
6. Define the term standardised fitness test.

**EXAM practice**
8. Identify and justify what type of testing is most likely to be used by a Year 12 Physical Education class to test aerobic power. 3 marks
9.2 The purpose of fitness testing

**KEY CONCEPT** When using fitness testing for training, the purpose is to ensure specificity and success. However, the specific purpose depends on the stage within the training program at which the testing is performed.

**Pre-training program testing**
Fitness testing before the season, once activity analysis is completed, should be performed as a minimum to ensure specificity. The results of pre-testing should provide the blueprint for the training program.

Pre-training program fitness testing aims to achieve the following goals.

**Assess strengths and weaknesses of participants**
Fitness tests identify an individual’s strengths and weaknesses in the major components of fitness that are important to a particular sport or activity. This information allows the design of a specific individual training program that is geared to maintaining strengths and improving weaknesses.

**Motivate participants**
Fitness test results that outline specific capacities and attributes, and identify individual strengths and weaknesses, can provide strong motivation and incentive for participants to continue training and to strive for improvement. This is particularly likely if the results are positively and constructively presented. Fitness testing is a way of predicting future performance and allowing the participant to know to what level they can realistically aim.

**Assess suitability of participants to a sport or position**
Fitness test results enable participants to ascertain their capacity to perform certain tasks. The tests can indicate specific personal attributes that the participant and coach can use to help determine the types of event or playing position to which the player is best suited. A soccer player who scores highly in a test of aerobic power, for example, may be best suited to playing as a midfielder or on-baller — roles that involve covering greater distances in the game — rather than in a set position such as goalie.

**Set benchmarks**
Collecting data from pre-training testing can allow the participant and coach to set ‘benchmarks’ for training. This data can also be referred to as baseline data. Collection of baseline data allows realistic and specific goals to be set and accurate evaluation to occur. This can be done at an individual level or a group level for team sports.

**Testing during training**
Fitness testing during a training program can help coaches evaluate how the participant and training program are going. The number of times testing is undertaken will depend on the length of the program. Testing should not occur any earlier than six weeks into a training program to allow chronic adaptations to occur (see chapter 12).

Testing during training aims to:
- motivate participants. Participants may have set goals and testing results may encourage the participant to maintain or improve in order to achieve their goal.
- evaluate the effectiveness of the program. Testing results will indicate if there have been improvements in fitness components. If the training program is effective, improvements would be expected. If this has not occurred, then the training program will need to be modified.

This type of feedback is vital in monitoring progress and training efficiency, as well as driving necessary modifications.
9.2 The purpose of fitness testing

Post-program testing

Post-program testing is completed once the training program is over. This provides vital information for the participant about the impact of the training program.

Post-training testing aims to:
- evaluate the effectiveness of the training program. If the training program has achieved its aims, it would suggest the methods and principles (chapter 11) have been applied correctly and that a similar process should be put in place for the next training program. If the training program has failed to achieve its aims, it would suggest significant modifications are required. This would involve reviewing the methods and principles put in place.
- review benchmarks. This will help determine how effective the program has been and also help in the preparation of future programs.
- motivate participants. Participants may be motivated by either positive or negative results.

The reason for testing will differ depending on when during the training program, the fitness testing is undertaken.

Choosing fitness tests

There are a number of factors that need to be considered when choosing appropriate fitness tests. As previously mentioned, the tests should replicate the requirements of the activity as identified in the activity analysis. Other considerations include the physiological, psychological and sociocultural perspectives.

**Physiological perspectives**

Fitness tests should be chosen taking into account physiological perspectives such as current fitness and health conditions. One of the most effective ways to gain information about the physiological state of a subject is through pre-participation health screening; PAR-Q.

Pre-participation health screening, most often done through a PAR-Q, is a vital component of fitness testing, particularly pre-training program testing. Pre-participation screening involves a series of questions about the participant’s current health. These often include questions about heart health, previous and current injuries and current exercise levels. This information can then be analysed to determine if fitness testing could be a risk for the individual. It can also be used to determine the level of risk and choose appropriate tests.

For example, you would not ask an overweight 50-year-old to complete a VO2 max. test or multi-stage fitness test — rather you may choose the Rockport 1.6 km walk. An overweight 50-year-old is unlikely to have high levels of aerobic power, so completing the VO2 max. test or multi-stage fitness test, which are exhausting in nature, may be physically dangerous for them. In contrast, the Rockport 1.6 km walk is a submaximal test and is therefore unlikely to put the participant at risk.
PAR-Q & YOU

(A Questionnaire for People Aged 15 to 69)

Regular physical activity is fun and healthy, and increasing more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active.

If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you whether or not you need to check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor.

Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly — check YES or NO.

YES NO
☐ 1. Has your doctor ever said that you have a heart condition and that you should do physical activity recommended by a doctor?
☐ 2. Do you feel pain in your chest when you do physical activity?
☐ 3. In the past month, have you had chest pain when you were not doing physical activity?
☐ 4. Do you lose your balance because of dizziness or do you ever lose consciousness?
☐ 5. Do you have a bone or joint problem (for example, back, knee or hip) that could be made worse by a change in your physical activity?
☐ 6. Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?
☐ 7. Do you know of any other reason why you should not do physical activity?

If you answered YES to one or more questions

Talk with your doctor by phone or in person BEFORE you start becoming much more physically active. BEFORE you have a fitness appraisal. Tell your doctor about the PAR-Q and which questions you answered YES.

• You may be able to do any activity you want — as long as you start slowly and build up gradually. Or, you may need to restrict your activities to those which are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice.

If you answered NO to all questions

• start becoming much more physically active — begin slowly and build up gradually. This is the safest and easiest way to go.

• take part in a fitness appraisal — this is an excellent way to determine your basic fitness so that you can plan the best way for you to live actively. It is also highly recommended that you have your blood pressure evaluated. If your reading is over 144/94, talk with your doctor before you start becoming much more physically active.


No changes permitted. You are encouraged to photocopy the PAR-Q but only if you use the entire form.

DELAY BECOMING MUCH MORE ACTIVE:

• if you are not feeling well because of a temporary illness such as a cold or a fever — wait until you feel better or

• if you are or may be pregnant — talk to your doctor before you start becoming more active.

PLEASE NOTE: If your health changes so that you then answer YES to any of the above questions, tell your fitness or health professional. Ask whether you should change your physical activity plan.

Informed Use of the PAR-Q: The Canadian Society for Exercise Physiology, Health Canada, and their agents assume no liability for persons who undertake physical activity, and if in doubt after completing the questionnaire, consult your doctor prior to physical activity.

No changes permitted. You are encouraged to photocopy the PAR-Q but only if you use the entire form.

I have read, understood and completed this questionnaire. Any questions I had were answered to my full satisfaction.

NAME ________________________________ DATE ________________

SIGNATURE ____________________________ WITNESS ____________________________

Note: This physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if your condition changes so that you would answer YES to any of the seven questions.

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Psychological perspectives

Like physiological perspectives, the current psychological state of a subject may influence the effectiveness of testing and should therefore be considered carefully when choosing appropriate fitness tests. Knowing the purpose of the testing for the individual is an important step in this.

A participant who wants to know their strengths and weaknesses may choose different tests to someone who is starting their first gym program. A coach and a personal trainer will test for different reasons and thus the tests chosen may differ.

A questionnaire, similar to a PAR-Q, can be used to determine the psychological state of the participant. Collecting such information is not only important in managing risks but can also provide vital information about the participant’s motivation and goals, which can help when choosing specific tests.

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9.2 The purpose of fitness testing

For example, a participant who is undertaking testing and a training program to improve their overall health and wellbeing is more likely to undergo the seven-stage abdominal strength test than a 1 RM bench press. A participant wanting to improve their athletic performance for rugby is more likely to undergo a 1 RM test.

For an example of an adult pre-test screening questionnaire from Exercise and Sports Science Australia, go to the Pre-test screening questionnaire digital document in your eBookPlus.

Sociocultural perspectives

It is important to recognise that sociocultural factors can affect the fitness tests that are available for use. When choosing a test, it is important to consider the resources available. Low socioeconomic status can restrict the number of tests available for use; for example, when measuring body composition, DEXA and TOBEC scans are expensive, so waist circumference measurements may have to be used instead. Whether you are testing an individual or a group will also impact your choice of test; for example, the 30-second Wingate test can only test one person at a time, whereas the Phosphate Recovery test can test large groups at once. In some cultures, it is not appropriate for women to expose skin, especially in the company of males, so to measure body composition skinfold measurements would not be appropriate but body mass index would be. When choosing fitness tests, you should be able to justify your choice considering these factors.

Fitness tests test battery

Testing sessions should be scheduled to coincide with the beginning and end of each training phase so that the effectiveness of the training phase can be assessed. Likewise, if a specific intervention has been programmed, pre- and post-testing is recommended to assess the impact of the intervention.

All test sessions should be scheduled at the same time of day to avoid fluctuations in physiological responses due to circadian rhythm (Winget et al., 1985) and to promote consistency in how the participant presents themself for each test session.

It is recommended that the field tests be completed in a standardised order. This order should be determined in light of physiological considerations; that is, the completion of one test should not adversely affect performance in subsequent tests, thus promoting optimal performance and allowing for a valid comparison to previous test results. This test order will also require minimal recovery time between tests, thus allowing for an overall efficient testing session.

For example:
Day 1: vertical jump, 20 m sprint, Illinois agility test, multi-stage fitness test, yo−yo test
Day 2: phosphate recovery test

TEST your understanding
1. Outline two reasons for pre-training program testing.
2. Outline two reasons for post-training program testing.
3. Discuss why six weeks of training is recommended between testing.
4. List three factors that should be taken into consideration when choosing fitness tests.

APPLY your understanding
5. Identify and justify the best aerobic power test for a Year 12 class of 25 students studying basketball.
6. Explain the purpose of a PAR-Q.
7. Discuss how testing mid-training program can be motivating.
8. Explain the importance of planning the order of fitness testing.

EXAM practice
9. Justify the use of field tests for a Year 12 class based on a psychological and sociocultural perspective.

2 marks
9.3 How to conduct fitness testing

**KEY CONCEPT** Successful fitness testing relies on sound procedures. There are many tests available for assessing each of the fitness components. It is therefore important to select tests carefully to ensure that the testing is valid, accurate and pertinent to the needs of the participant.

**Test protocols**

Ensuring the participant has a clear understanding of the testing process will help the subject, no matter the purpose, prepare from a psychological perspective. Players’ rights and facilitators’ responsibilities are an essential aspect of fitness and training. Before any fitness tests are carried out, it is essential that all facilitators clarify all testing procedures and risks to their participants. Participants should be clearly informed about the nature of the fitness for sporting situation testing they are being directed to undertake, including:

- aims of testing
- methods of testing
- safeguards for testing (those responsible for managing fitness testing procedures must be qualified and experienced in all fitness-testing protocols).

The best way to ensure the above is to get the participants’ informed consent.

**Informed consent**

Most accredited fitness centres now have standard forms for their clients to complete that give their acknowledgement of risks associated with the fitness testing and training programs they are about to undertake. These forms may also acknowledge that all fitness test results are confidential and only to be used for agreed personal fitness or sports training outcomes. Informed consent aims to protect the interests of both the testing organisation and subjects. It has both legal and ethical implications.

Informed consent should:

- Clearly identify the testing organisation and the departments or individuals involved in conducting the testing.
- Clearly explain the nature of any sport science test to be performed. This should include any possible risks.
- Clearly outline that the individual can withdraw consent, freely and without prejudice, at any time before, during, or after testing.
- Outline the specific uses of the information obtained from the testing sessions and ensure that the confidentiality of information obtained during testing will be protected.
- Require participants to advise the tester if they have any injury, illness, or physical defect at the time of testing. Ideally also complete a PAR-Q (see figure 9.3).
- Outline the risks of the testing.
- Obtain the participant’s signature. When the participant is less than 18 years of age and the consent of a parent or guardian is required, the consent documentation should provide a statement for the parent or guardian to sign.

**Test reliability and validity**

An appropriate fitness test must be valid; that is, it should measure what it claims to measure. If a test claims to measure aerobic power, for example, then it should be of sufficient duration to test the capacity of this energy system.

A fitness test must also be reliable — it must be able to be replicated with consistency. For a test to be reliable, the only variable that should change between tests is the participant. Reliability depends on a number of factors remaining constant, so the following elements are vital (as far as possible) on each test occasion:

- performing the same warm-up
- conducting the same sequence of tests
9.3 How to conduct fitness testing

INFORMED CONSENT FOR EXERCISE TESTING

I hereby voluntarily give consent to engage in a fitness test. I understand that the cardiovascular fitness test will involve progressive stages of increasing effort and that at any time I may terminate the test for any reason. I understand that during some tests I may be encouraged to work at maximum effort and that at any time I may terminate the test for any reason.

I understand there are certain changes that may occur during the exercise test. They include abnormal blood pressure, fainting, disorders of heartbeat, and very rare instances of heart attack. I understand that every effort will be made to minimise problems by preliminary examination and observation during testing.

I understand that I am responsible for monitoring my own condition throughout testing, and should any unusual symptoms occur, I will cease my participation and inform the test administrator of the symptoms. Unusual symptoms include, but are not limited to chest discomfort, nausea, difficulty in breathing, and joint or muscle injury.

Also, in consideration of being allowed to participate in the fitness test, I agree to assume all risks of such fitness testing, and hereby release and hold harmless ___________________________, and their agents and employees, from any and all health claims, suits, losses or causes of action for damages, for injury or death, including claims for negligence, arising out of or related to my participation in the fitness assessments.

I have read the foregoing carefully and I understand its content. Any questions that may have occurred to me concerning this informed consent have been answered to my satisfaction.

Name Date
Witness Date

FIGURE 9.4 All accredited fitness centres have standard release forms.

○ providing the same recovery period between tests
○ testing the participant at approximately the same time of day
○ testing the participant when they are in a similar hydration and nutritional state
○ conducting the tests in similar environmental conditions (heat, humidity and air movement).

Trained and experienced administrators of the tests are also required to ensure reliability. It is important that the person conducting the testing always does so to the best of their ability, under the most stable and reliable conditions.

The results of the selected tests must be interpretable and comparable, and the participant should receive feedback about:

○ what the results represent (good, average or poor performance)
○ how the results compare with previous results
○ how the results compare with those of other participants in the reference group
○ the consequences and implications of the results.

TEST your understanding

1 Outline the essential criteria for successful fitness testing.
2 List the ways to ensure a fitness test can be accurately repeated after a period of weeks or months.
3 Discuss the importance of informed consent.
4 Suggest two situations where informed consent may need to be gained from someone other than the participant.

APPLY your understanding

5 Practical activity: protocols of fitness testing (fitness centre)
In groups, visit a local fitness centre and interview management staff on their centre’s procedures for conducting fitness testing with their clients. Ask for samples of any paperwork used. Write a report that assesses the centre’s methods.

EXAM practice

6 Outline three ways in which a testing facilitator can ensure testing can be completed with minimal risks. 3 marks
9.4 Fitness tests

**KEY CONCEPT** Fitness tests should be chosen based on the activity analysis. There are multiple tests for each fitness component and each test should replicate the requirements (movement patterns and muscle movements) of the activity and meet the physiological, psychological and sociocultural needs of the individual.

**TABLE 9.1** Recognised standardised tests

<table>
<thead>
<tr>
<th>Fitness component</th>
<th>Test</th>
</tr>
</thead>
</table>
| Aerobic power     | Multi-stage fitness test  
Yo-yo test  
Cooper 12-minute run test  
2.4 km run test  
Rockport 1.6 km walking test  
VO₂ max. Astrand–Ryhming cycle ergometer test  
VO₂ max. treadmill test  
Harvard step-test |
| Agility           | Illinois agility test  
Semo agility test  
5-0-5 agility test |
| Anaerobic capacity | Phosphate recovery test  
30-second Wingate test  
Repco peak power test |
| Body composition  | Body mass index  
Waist circumference  
Skinfold measurements  
Hydrodensitometry (underwater) weighing  
Bioelectrical impedance  
DEXA and TOBEC scans |
| Flexibility       | Trunk flexion (sit-and-reach) test  
Trunk rotation test  
Groin flexibility test  
Shoulder and wrist elevation test  
Trunk and neck extension test  
Ankle extension/dorsiflexion test  
Shoulder rotation test |
| Muscular Endurance | 60-second push-up test  
30-second sit-up test  
Curl-up (crunch) test  
Pull-up/modified pull-up test  
Flexed arm hang test |
| Power             | Basketball throw  
Vertical jump  
Standing long jump  
Magaria Kalamen stair sprint test |
| Strength          | 1 RM (bench press, back squat, leg press)  
Grip strength dynamometer  
Push–pull dynamometer  
Seven-stage abdominal strength test |
| Speed             | 20-metre sprint test  
35-metre sprint test  
50-metre sprint test |
9.4  Fitness tests

**Aerobic power tests**

Aerobic power — the rate at which aerobic metabolism can supply energy through the use of the aerobic pathway — can be assessed in a number of ways. An individual can ascertain the efficiency of their aerobic pathway by assessing their maximum oxygen uptake. Maximal aerobic power can be determined by either maximal tests, in which the individual works to their maximum or exhaustion, or submaximal tests, in which the individual works less intensely to determine a predicted maximum oxygen uptake.

**Multi-stage fitness test**

The multi-stage fitness test (also known as the beep test) was developed by Leger and Lambert. The nature of the short runs and turns in this test link closely with most team sports, but they are not a good indicator for sports that require consistent motion such as cycling, running or rowing.

**Aim**

To keep up with the beeps for as long as possible.

**Equipment**

- Flat 20-metre stretch of suitable floor space
- Marking cones
- Multi-stage fitness test audio recording

**Method**

1. Measure out a 20-metre section of floor space (the shuttle).
2. The participant must arrive at the end of the shuttle before the beep.
3. For the first minute the beeps on the audio recording will sound at the rate for the participant to travel at a speed of 8.5 kilometres per hour, and will then increase in speed by 0.5 kilometres per hour each minute following.
4. When the participant fails to arrive at the end of the shuttle by the beep they withdraw and their level is recorded.

**Results**

1. Enter the participant’s results into the multi-stage VO₂ calculator.
2. Consult the ratings in table 9.2 for the participant’s aerobic fitness level.

**TABLE 9.2 Predicted VO₂ max readings for the multi-stage fitness test**

<table>
<thead>
<tr>
<th>Rating</th>
<th>Males aged 13–19 years (ml/kg/min)</th>
<th>Females aged 13–19 years (ml/kg/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superior</td>
<td>&gt; 55.9</td>
<td>&gt; 41.9</td>
</tr>
<tr>
<td>Excellent</td>
<td>51.0–55.9</td>
<td>39.0–41.9</td>
</tr>
<tr>
<td>Good</td>
<td>45.2–50.9</td>
<td>35.0–38.9</td>
</tr>
<tr>
<td>Fair</td>
<td>38.4–45.1</td>
<td>31.0–34.9</td>
</tr>
<tr>
<td>Poor</td>
<td>35.0–38.3</td>
<td>25.0–30.9</td>
</tr>
<tr>
<td>Very poor</td>
<td>&lt; 35.0</td>
<td>&lt; 25.0</td>
</tr>
</tbody>
</table>

**Source:** Heyward, VH 1998, The physical fitness specialist certification manual, 3rd edn, The Cooper Institute for Aerobics Research, Dallas TX, p. 48.
It is important to note that different sports will have different means and ranges for aerobic power. For example, the AIS has the following norms for the following sports at the national level:

| TABLE 9.3 Multi-stage fitness test norms (level achieved) for various sports according to the AIS |
|---------------------------------|---------|--------|---------|
| Sport                          | Sex     | Age    | Mean score |
| AFL — AIS                       | Male    | Approx. 18 | 13.5     |
| Hockey — national              | Female  | U21    | 11.9     |
| Hockey — national              | Male    | U21    | 14.9     |
| Tennis — national              | Female  | 16+    | 11.2     |
| Tennis — national              | Male    | 16+    | 13.4     |

**Yo-yo test**

**Aim**
To keep up with the audio recording as long as possible

**Equipment**
- Measuring tape
- Cones/markers
- Yo-yo audio recording

**Method**
1. Measure out a 20 m test course as per figure 9.4.
2. Place markers 2 m apart at both ends of the 20 m test course (i.e. at start and turning lines).
3. In addition to marking the 20 m line, measure out a 5 m distance behind the start line.
4. Place a marker on the recovery line aligned to the middle of the two markers on the start line.
5. Participants assume a starting position on the start line.
6. The yo-yo test audio is started. (There are two levels of audio available: level 1 for beginners and level 2 is advanced. For VCE Physical Education, Level 1 is recommended.)
7. At the time of the first signal, the participants run forward to the turning line. At the sound of the second signal, participants arrive and turn at the turning line and then run back to the start line arriving on the next beep. When the start marker is passed, the participants continue forward at a reduced pace (jogging) toward the 5 m mark, where they then turn around the cone and return to the start line. At this point, the participants stop and wait for the next signal to sound. It is important that the participants are stationary on the start line before the commencement of each sprint.

8. Participants are required to place one foot either on or over the start or turning lines at the sound of each beep.

9. Participants should continue running for as long as possible, until they are unable to maintain the speed as indicated by the audio.

10. The end of the test is indicated by the inability of a participant to maintain the required pace for two trials. The first time the start line is not reached, a warning is given; the second time the participant must withdraw.

11. When the participant withdraws, the last level and the number of $2 \times 20$-m intervals performed at this level are recorded on the appropriate recording sheet. (The last $2 \times 20$-m interval is included, even if the participant did not complete at the right pace.) For valid results, participants must attempt to reach the highest level possible before stopping.

12. Yo-yo test predicted $\text{VO}_{2 \text{ max}}$ (ml/kg/L min$^{-1}$) $= \text{IRT} \times \text{distance (m)} \times 0.0084 + 36.4$

See $\text{VO}_{2 \text{ max}}$ norms, page 294.

For example:

17 year old female achieves a score of $15.6 = 1000 \times 0.0084 + 36.4 = 44.8 \text{ ml/kg/min}$

This would be considered good.

### Results

**TABLE 9.4. Yo-yo test norms**

#### Level 1 norms for adult men and women

<table>
<thead>
<tr>
<th>Rating</th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Metres</td>
<td>Level</td>
</tr>
<tr>
<td>Elite</td>
<td>&gt; 2400</td>
<td>&gt; 20.0</td>
</tr>
<tr>
<td>Excellent</td>
<td>2000–2400</td>
<td>18.7–20.0</td>
</tr>
<tr>
<td>Good</td>
<td>1520–2000</td>
<td>17.3–18.7</td>
</tr>
<tr>
<td>Average</td>
<td>1000–1520</td>
<td>15.6–17.3</td>
</tr>
<tr>
<td>Very poor</td>
<td>&lt; 520</td>
<td>&lt; 14.2</td>
</tr>
</tbody>
</table>
Level 2 norms for adult men and women

<table>
<thead>
<tr>
<th>Rating</th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Metres</td>
<td>Level</td>
</tr>
<tr>
<td>Elite</td>
<td>&gt; 1280</td>
<td>&gt; 16.5</td>
</tr>
<tr>
<td>Excellent</td>
<td>1000–1280</td>
<td>15.6–16.5</td>
</tr>
<tr>
<td>Very poor</td>
<td>&lt; 280</td>
<td>&lt; 12.3</td>
</tr>
</tbody>
</table>

It is important to note that different sports will have different means and ranges for aerobic power. For example, the AIS has the following norms for the following sports at the national level.

**TABLE 9.5 Yo-yo test norms for various sports according to the AIS**

<table>
<thead>
<tr>
<th>Sport</th>
<th>Sex</th>
<th>Age</th>
<th>Mean level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Netball — national</td>
<td>Female</td>
<td>U17</td>
<td>15.7</td>
</tr>
<tr>
<td>Soccer — national</td>
<td>Male</td>
<td>U17</td>
<td>20.6</td>
</tr>
<tr>
<td>Basketball — state</td>
<td>Female</td>
<td>U17</td>
<td>15.6</td>
</tr>
<tr>
<td>Basketball — state</td>
<td>Male</td>
<td>U17</td>
<td>16.2</td>
</tr>
</tbody>
</table>

**Cooper 12-minute run test**

Dr Kenneth Cooper devised this test in 1968 and its popularity reflects its ease of implementation. It is based on the assumption that an individual will run a greater distance within the time limit if they have a well-developed aerobic capacity.

**Aim**

To run as far as possible in 12 minutes

**Equipment**

- Athletics track or oval, preferably with a lap length of 200–400 metres.
- One marking cone for every 20 metres of track
- Stopwatch
- Measuring wheel to calculate lap distance and intervals
- Whistle

**NOTE**

If students have access to a tracking technology such as an app or GPS watch these can be a more efficient way of measurement.

**Method**

1. Place cones every 20 metres for easy calculation of distance covered.
2. The participant aims to complete as many laps as possible within the 12-minute time limit by running.
3. When the whistle blows to end the time period, the participant walks to the nearest marker.
4. Calculate the number of laps completed and the number of metres covered in the final lap.

**Results**
1. Calculate and record the total metres covered.
2. Consult the ratings in table 9.6 for the participant's aerobic fitness level.

**TABLE 9.6 Ratings for Cooper's 12-minute run test (metres covered)**

<table>
<thead>
<tr>
<th>Rating</th>
<th>Males aged 15–16 years</th>
<th>Females aged 15–16 years</th>
<th>Males aged 17–19 years</th>
<th>Females aged 17–20 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>&gt; 2800</td>
<td>&gt; 2100</td>
<td>&gt; 3000</td>
<td>&gt; 2300</td>
</tr>
<tr>
<td>Above average</td>
<td>2500–2800</td>
<td>2000–2100</td>
<td>2700–3000</td>
<td>2100–2300</td>
</tr>
<tr>
<td>Average</td>
<td>2300–2499</td>
<td>1700–1999</td>
<td>2500–2699</td>
<td>1800–2099</td>
</tr>
<tr>
<td>Below average</td>
<td>2200–2299</td>
<td>1600–1699</td>
<td>2300–2499</td>
<td>1700–1799</td>
</tr>
<tr>
<td>Poor</td>
<td>&lt; 2200</td>
<td>&lt; 1600</td>
<td>&lt; 2300</td>
<td>&lt; 1700</td>
</tr>
</tbody>
</table>

2.4 km run test

**Aim**
The aim of this test is to complete the 2.4 km course in the shortest possible time.

**Equipment**
- 2.4 km flat and hard running course
- Stopwatch

**Method**
1. Participants line up behind the starting line
2. On the command 'go,' the clock is started and they begin running at their own pace.
3. Time stops when participant reaches 2.4 km.
4. Although walking is allowed, it is strongly discouraged.

**Results**
You can predict VO₂ max. from the test, where VO₂ max. units is ml.kg.min⁻¹, and time in minutes.

\[
VO₂ \text{ max.} = (483/\text{time}) + 3.5
\]

Compare to relevant VO₂ max. norms (see page 294).
Rockport 1.6 km walking test

Aim
The purpose of this test is to walk as fast as possible for 1.6 km (1 mile).

Equipment
- Flat 1.6 km track
- Stopwatch
- Heart rate monitor (if possible)

Method
1. Walk for 1.6 km and record the time taken.
2. After you have completed the distance, immediately take your heart rate. If you do not have a heart rate monitor, you can manually count the number of beats for 20 seconds (using carotid or wrist pulse), and then multiply that by three to get your minute heart rate.

Results
Use the time taken, your body weight in pounds (1 kg = 2.20462 pounds), age and finishing heart rate in the following equation.

Females: \( \text{VO}_2 = 139.168 - (0.388 \times \text{age}) - (0.077 \times \text{weight in lb.}) - (3.265 \times \text{walk time in minutes}) - (0.156 \times \text{heart rate}) \)

Males: add 6.318 to the equation for females above.

Compare to relevant VO\(_2\) max. norms (see page 294).

VO\(_2\) max. Astrand–Ryhming cycle ergometer test/VO\(_2\) max. treadmill test

Aim
The lower the heart rate during the test, the more efficient the aerobic energy system.

Equipment
- Cycle ergometer
- Clock or stopwatch
- Heart rate monitor
- ECG monitor (optional)

Method
1. Participants pedal on a cycle ergometer at a constant workload for 7 minutes.
2. Heart rate is measured every minute, and the steady state heart rate is determined.

Results
Females: \( \text{VO}_2 \) max. = \( \frac{(0.00193 \times \text{workload} + 0.326)}{(0.769 \times \text{HRss} - 56.1) \times 100} \)

Males: \( \text{VO}_2 \) max. = \( \frac{(0.00212 \times \text{workload} + 0.299)}{(0.769 \times \text{HRss} - 48.5) \times 100} \)

Compare to VO\(_2\) max. norms (see page 294).
Harvard step-test (short form)

Aim
To maintain the stepping rate with a low heart rate. The higher the fitness index, the higher the aerobic power.

Equipment
○ Step or platform 20 inches (50.8 cm) high
○ Stopwatch
○ Metronome or cadence audio recording

Method
1. The participant steps up and down on the platform at a rate of 30 steps per minute (every two seconds) for 5 minutes or until they cannot maintain the stepping rate for 15 seconds.
2. The participant immediately sits down on completion of the test, and heart rate is measured between 1 to 1.5 minutes after finishing.

Results
Fitness index (short form) = \( \frac{100 \times \text{test duration in seconds}}{5.5 \times \text{heart rate between 1 and 1.5 minutes}} \)

Fitness index score is determined by the above equation. For example, if the total test time was 300 seconds (i.e. the whole 5 minutes was completed), and the number of heart beats between 1–1.5 minutes was 90, between 2–2.5 it was 80 and between 3–3.5 it was 70.

Note: You are using the total number of heart beats in the 30-second period, not the rate (beats per minute) during that time.

TABLE 9.7 Harvard step-test fitness norms

<table>
<thead>
<tr>
<th>Rating</th>
<th>Fitness index (long form)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>&gt; 96</td>
</tr>
<tr>
<td>Good</td>
<td>83–96</td>
</tr>
<tr>
<td>Average</td>
<td>68–82</td>
</tr>
<tr>
<td>Low average</td>
<td>54–67</td>
</tr>
<tr>
<td>Poor</td>
<td>&lt; 54</td>
</tr>
</tbody>
</table>

(norms from: Fox et al. 1973)
Anaerobic capacity tests

Anaerobic capacity (or anaerobic metabolism) involves two energy systems — the ATP–CP system and the anaerobic glycolysis system. Anaerobic capacity tests are designed to measure the total amount of energy provided by the anaerobic energy systems.

Phosphate recovery test

This test was originally developed for Australian Rules football, but it is suitable for a variety of sports that involve repeated high-intensity, short-duration efforts. The test stresses the ability of the body to replenish high-energy phosphates between each repetition of the test.

Aim

To sprint past as many cones as possible for each sprint.

Equipment

- Marking cones of various colours, with two sets numbered 1–10
- Stopwatches
- Whistle
- Recording sheets
- Appropriate area such as an oval

Method

1. Set up the course as shown in figure 9.7. Place the cones numbered 1–10 every 2 metres from the centre in the formation shown.
2. Participants work in pairs, with one partner running while the other records. They then reverse roles. Each participant should be thoroughly familiar with the test protocol.
3. A timekeeper, who works with two stopwatches and a whistle, controls the test.
4. Each participant performs one of the following sets:
   - $8 \times 7$-second sprints, departing every 30 seconds (work-to-rest ratio of 1:3.3)
   - $8 \times 5$-second sprints, departing every 30 seconds (work-to-rest ratio of 1:5).
5. Participants must perform each sprint at maximum effort. The timekeeper blows the whistle to start and stop each sprint.
6. Both stopwatches are started as the sprint begins. Watch 1 is clocked off at 7 or 5 seconds (according to the set), with an appropriate whistle signal to the runner. Watch 2 continues ticking over as the participant jogs or walks to the other end of the course.
7. At 30 seconds (watch 2) the timekeeper blows the whistle to begin the next sprint. Timing of the sprint should begin on watch 1.
8. This procedure is repeated until participants have completed eight sprints. Refer to figure 9.8 for a sample procedure to follow.

![FIGURE 9.8 Phosphate recovery test course](Image)

<table>
<thead>
<tr>
<th>Signal (stopwatch 2) (minutes: seconds)</th>
<th>Action — runners</th>
<th>Timekeeper</th>
<th>Scorer(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘Set’</td>
<td>Line up</td>
<td>Set both stopwatches to zero</td>
<td>Line up with markers in position 1 in direction of sprint</td>
</tr>
<tr>
<td>Whistle (go)</td>
<td>Sprint as quickly as possible for 7 seconds — sprint 1</td>
<td>Stopwatch 1: start Stopwatch 2: start</td>
<td>Ready</td>
</tr>
<tr>
<td>‘Stop’ (00:07)</td>
<td>Jog through to far line</td>
<td>Stopwatch 1: stop, reset Stopwatch 2: allow to run</td>
<td>Count number of markers passed at ‘stop’ (if between markers, count last marker passed). Record score, e.g. 8</td>
</tr>
<tr>
<td>‘Set’ (00:25)</td>
<td>Line up to sprint back in opposite direction</td>
<td>Stopwatch 1: on zero Stopwatch 2: on 25 second ‘set’</td>
<td>Move to line up with second lot of markers at position 2</td>
</tr>
<tr>
<td>Whistle (00:30)</td>
<td>Sprint 2</td>
<td>Stopwatch 1: start Stopwatch 2: on 30 second (whistle)</td>
<td>Ready</td>
</tr>
</tbody>
</table>
### Signal (stopwatch 2) (minutes: seconds)

<table>
<thead>
<tr>
<th>Signal</th>
<th>Action — runners</th>
<th>Timekeeper</th>
<th>Scorer(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘Stop’ (00:37)</td>
<td>Jog to end</td>
<td>Stopwatch 1: stop (7 second), reset Stopwatch 2: on 37 second</td>
<td>Record second score, e.g. 7 Move back to original position</td>
</tr>
<tr>
<td>‘Set’ (00:55)</td>
<td>Line up</td>
<td>Stopwatch 1: on zero Stopwatch 2: on 55 second ‘set’</td>
<td>Move back to original position 1</td>
</tr>
<tr>
<td>Whistle (01:00)</td>
<td>Sprint 3</td>
<td>Stopwatch 1: start (whistle) Stopwatch 2: on 60 second</td>
<td>Ready</td>
</tr>
<tr>
<td>‘Stop’ (01:07)</td>
<td>Jog to end</td>
<td>Stopwatch 1: stop (7 second), reset Stopwatch 2: on 60 second</td>
<td>Record third score, e.g. 6</td>
</tr>
<tr>
<td>‘Set’ (01:25)</td>
<td>Line up</td>
<td>Stopwatch 1: zero Stopwatch 2: on 85 second ‘set’</td>
<td>Move to position 2</td>
</tr>
<tr>
<td>Whistle (01:30)</td>
<td>Sprint 4</td>
<td>Stopwatch 1: start (whistle) Stopwatch 2: on 90 second</td>
<td>Ready</td>
</tr>
<tr>
<td>‘Stop’ (01:37)</td>
<td>Jog to end</td>
<td>Stopwatch 1: stop (7 second), reset Stopwatch 2: on 90 second</td>
<td>Record fourth score, e.g. 4</td>
</tr>
</tbody>
</table>

*Continue* this procedure for eight sprints (total elapsed time = 3 minutes 37 seconds).

**FIGURE 9.9** Sample procedure for the phosphate recovery test, 8 × 7-second sprints departing every 30 seconds

### Scoring

1. Record scores on the recording sheet (see figure 9.9).
2. Scorers must be in position to accurately read scores from the two sets of numbered cones. When the participants sprint from left to right, they are scored using the top set of numbered cones; when running right to left, they are scored using the bottom set of numbered cones.
3. The participants score points for each repetition according to the number of cones they have passed when the whistle blows to signify the end of the sprint.

### Results

1. Calculate the total score by adding the points from each sprint repetition (figure 9.9).
2. Calculate the best possible score by multiplying the best single score by the number of repetitions.
3. Calculate the total decrement score (value that reflects the decline in performance scores relative to a best possible score) by subtracting the total score from the best possible score.
4. Calculate the percentage decrement score by dividing the total decrement score by the best possible score and multiplying by 100.
5. Refer to table 9.8 to obtain ratings for the percentage decrement. The lower the total decrement and percentage decrement scores, the better the result.

**TABLE 9.8** Percentage decrement ratings for the phosphate recovery test

<table>
<thead>
<tr>
<th>Rating</th>
<th>Percentage decrement score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>&lt; 12</td>
</tr>
<tr>
<td>Good</td>
<td>12–19</td>
</tr>
<tr>
<td>Average</td>
<td>20–29</td>
</tr>
<tr>
<td>Fair</td>
<td>30–40</td>
</tr>
<tr>
<td>Poor</td>
<td>&gt; 40</td>
</tr>
</tbody>
</table>


**30-second Wingate test**

**Aim**
To pedal as fast as possible for 30 seconds

**Equipment**
- Stationary exercise bike

**Method**
1. The participant should first perform a cycling warm-up of several minutes.
2. The participant is instructed to pedal as fast as possible for 30 seconds.
3. In the first few seconds, the resistance load is adjusted to the pre-determined level, which is usually about 45 g/kg body weight (Fleisch) or 75 g/kg body weight (Monark) for adults.
**Results**

Some of the measures that can be gained from this test are mean and peak power (ideally measured in first five second interval of the test, expressed in Watts), relative peak power (determined by dividing peak power by body mass, expressed as W/kg), mean peak power, minimum peak power, and a fatigue index determined from the decline in power.

Power Output ($\text{kpm} \cdot \text{min}^{-1}$) = \[ \frac{\text{revs} \times \text{resistance (kg)} \times \text{dist (m)} \times 60 \ (\text{sec})}{\text{time (sec)}} \]

Watts/kg = Watts / body weight (kg)

Fatigue Index = \[ \frac{(\text{Peak Power Output} - \text{Min Power Output})}{\text{Peak Power Output}} \] \times 100

<table>
<thead>
<tr>
<th>% Rank</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>90</td>
<td>822</td>
<td>560</td>
</tr>
<tr>
<td>80</td>
<td>777</td>
<td>527</td>
</tr>
<tr>
<td>70</td>
<td>757</td>
<td>505</td>
</tr>
<tr>
<td>60</td>
<td>721</td>
<td>480</td>
</tr>
<tr>
<td>50</td>
<td>689</td>
<td>449</td>
</tr>
<tr>
<td>40</td>
<td>671</td>
<td>432</td>
</tr>
<tr>
<td>30</td>
<td>656</td>
<td>399</td>
</tr>
<tr>
<td>20</td>
<td>618</td>
<td>376</td>
</tr>
<tr>
<td>10</td>
<td>570</td>
<td>353</td>
</tr>
</tbody>
</table>

**Repco peak power (phosphate power) test**

The Repco peak power test can be quickly and easily administered. It assesses phosphate power output while cycling on a bicycle ergometer. It can also be adapted to involve arm cranking.

**Equipment**
- Cycle ergometer (Repco is recommended)
- Stopwatch
- Weight scales

**Method**
1. Weigh the participant before the test (in kilograms).
2. Set up the cycle ergometer to suit the physique of the participant. Adjust seat height so that the leg is almost fully extended when the pedal is at the lowest point.
3. The participant performs a light cycle as a warm-up.
4. When indicated, the participant stands on the pedals and accelerates to maximum power, which they maintain for 10 seconds.
5. Allow two trials with at least a 3-minute rest between trials.
9.4 Fitness tests

Results
1. Record the maximum workload (in watts, indicated on the speedometer of the Repco cycle ergometer) reached during the test.
2. Divide the maximum workload (watts) by the weight of the participant (kilograms).
3. Obtain a rating for peak power output from table 9.10.

<table>
<thead>
<tr>
<th>TABLE 9.10 Peak power test index ratings (watts per kilogram)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rating</td>
</tr>
<tr>
<td>-------------------</td>
</tr>
<tr>
<td>Excellent</td>
</tr>
<tr>
<td>Very good</td>
</tr>
<tr>
<td>Good</td>
</tr>
<tr>
<td>Average</td>
</tr>
<tr>
<td>Fair</td>
</tr>
<tr>
<td>Poor</td>
</tr>
</tbody>
</table>

TEST your understanding
1 Define the term aerobic power.
2 Define the term anaerobic capacity.
3 List the common characteristics of reliable aerobic power tests.
4 List the common characteristics of reliable anaerobic capacity tests.

APPLY your understanding
5 Practical activity
   (a) Complete as many aerobic power and anaerobic capacity tests as you can.
   (b) Compare your ratings for at least two aerobic power tests. Were they similar or different? Explain why this may be so.
   (c) Compare your ratings for at least two anaerobic capacity tests. Were they similar or different? Explain why this may be so.
   (d) Describe each of the tests and identify one sport they might be suited to.

EXAM practice
6 Identify and justify an appropriate aerobic power test for the following participant/s. 6 marks
   – Olympic road cyclist
   – Beginner at the gym
   – Year 12 class

7 Identify and justify an appropriate anaerobic capacity test for the following participant/s. 6 marks
   – AFL footballer
   – Beginner at the gym
   – Year 12 class
9.5 Muscular strength, power and endurance tests

**KEY CONCEPT** As muscular strength, power and endurance have different requirements, they are tested differently. Muscular strength tests involve working until maximum effort is achieved. Muscular power tests require maximal distance and endurance tests require as many repetitions as possible in a set time or working as long as possible.

**Muscular strength tests**

Muscular strength is defined as the maximum effective force that a muscle or muscle group can exert once. It is therefore classically assessed through tests that measure the amount of force produced with a single maximal effort. A range of tests can be used that assess either the single or repeat maximal capacity (usually up to 3 RM) of different muscles and muscle groups. It is important to note that muscular strength can vary dependent on the muscle and/or muscle group, therefore a number of tests may be required to gain a more accurate assessment of strength.

**One repetition maximum (1 RM) test**

The one repetition maximum (1 RM) test is a popular method of measuring isoinertial muscle strength. It is a measure of the maximal weight a participant can lift with one repetition. Most commonly used movements are the bench press and leg press. However, 1 RM testing may not be recommended for some populations, including the elderly, cardiac patients, adolescents and some sedentary populations. For these populations other options for assessing strength should be used.

**Aim**

To lift as much as you can for one repetition only

**FIGURE 9.12** 1 RM leg press

**FIGURE 9.13** 1 RM leg press

**FIGURE 9.14** The 1 RM bench press
Muscular strength, power and endurance tests

9.5

Equipment
- Free weights (barbells) or other gym equipment

Method
A number of different procedural protocols exist. The following outline is one such protocol.

1. Begin with a warm-up of 5–10 repetitions at 40–60 per cent of the participant's estimated maximum weight.
2. After a brief rest period (3–5 minutes), increase the load to 60–80 per cent of the participant's estimated maximum, and the participant attempts to complete 3–5 repetitions.
3. At this point a small increase in weight is added to the load and a 1 RM lift is attempted.
4. If successful, wait another 3–5 minutes, add a small amount of weight and have the participant attempt one more repetition.
5. Keep adding small amounts of weight until the participant cannot successfully lift the weight.
6. The goal is to determine the participant's 1 RM in 3 to 5 trials.
7. The participant should be allowed ample rest (at least 3–5 minutes) before each 1 RM attempt.
8. The last successful completed repetition, with no assistance from a spotter, is the participant's repetition maximum.

(Note: A spotter should always be employed during the performance of this test and trained personnel should supervise the testing.)

Results
1. Take the participant's 1 RM weight and divide it by their body weight (in kilograms). For example, if they bench-pressed 120 kilograms and weigh 80 kilograms, the score is 1.5.
2. Refer to table 9.11 to obtain ratings for this test.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>1.4</td>
<td>0.7</td>
<td>2.8</td>
<td>2.2</td>
</tr>
<tr>
<td>Very good</td>
<td>1.2</td>
<td>0.6</td>
<td>2.4</td>
<td>2.0</td>
</tr>
<tr>
<td>Good</td>
<td>1.0</td>
<td>0.5</td>
<td>2.0</td>
<td>1.8</td>
</tr>
<tr>
<td>Fair</td>
<td>0.8</td>
<td>0.4</td>
<td>1.8</td>
<td>1.4</td>
</tr>
<tr>
<td>Poor</td>
<td>0.6</td>
<td>0.3</td>
<td>1.4</td>
<td>1.2</td>
</tr>
</tbody>
</table>


Grip strength dynamometer

The grip strength dynamometer test is one of the most popular strength tests. It is easy to perform and reliable in providing an index of muscular strength because it has a reasonably high correlation with total body strength. Norms for the test are also readily available, and the dynamometer is relatively inexpensive.

Aim
To squeeze your hand as hard as possible
Equipment
- Handgrip dynamometer

Method
1. First adjust the dynamometer to suit the participant’s hand size. The second joint of the fingers should fit comfortably under the handle.
2. The participant (in a standing position) holds the dynamometer above their body and lowers it to their side while squeezing vigorously (for approximately 5–10 seconds), exerting their maximum force. Ensure the dial of the dynamometer faces away from the participant’s body.
3. During the test, do not allow either the dynamometer or the participant’s hand to come into contact with the participant’s body.
4. Three trials are recommended for each hand, with a 3-minute rest between trials.

Results
1. Record the best score for each hand (in kilograms), as read from the dial.
2. Refer to table 9.12 to obtain ratings for grip strength.

| TABLE 9.12 Handgrip strength norms and ratings (kilograms) |
|---------------------------------|-----------------|-----------------|-----------------|-----------------|
| Rating                         | Males aged 16–17 years | Males aged 18–39 years | Females aged 16–17 years | Females aged 18–39 years |
| Excellent                      | 41 or more        | 54 or more        | 31 or more        | 39 or more        |
| Good                           | 36–40             | 50–53             | 29–30             | 36–38             |
| Average                        | 34–35             | 47–49             | 27–28             | 33–35             |
| Fair                           | 32–33             | 43–46             | 22–26             | 30–32             |
| Poor                           | 31 or less        | 42 or less        | 21 or less        | 29 or less        |

Source: Adapted from Leelarthaepin, B. 1992, Assessment of physical fitness: a practical approach, Biomediscience Services, New South Wales.

Push–pull dynamometer

The push–pull dynamometer enables an assessment of the strength of the upper back muscles (pull) and the chest and shoulder muscles (push). The test is simple to complete and the dynamometers are relatively inexpensive.

Aim
To pull and then push using your arms as much as possible

Equipment
- Push–pull dynamometer

Method
1. The participant holds the dynamometer with both hands in front of their chest, with the dial facing away from their body and the reading at zero (see figure 9.14).
2. They then pull the handles outwards and apart with as much force as possible for approximately 5–10 seconds. After a rest for 3 minutes, they repeat the action.

FIGURE 9.15 The push–pull dynamometer test
3. The participant then pushes the handles inwards and together with as much force as possible for approximately 5–10 seconds. Again, after a rest for 3 minutes, the participant repeats the action.

Results
Record the participant’s best attempt for both the pull and push phases of the test.
(Note: No relevant norms are available for this test.)

Seven-stage abdominal strength test

Aim
To complete a sit-up as the difficulty increases

Equipment
- Flat surface
- 5 lb (2.5 kg) and 10 lb (5 kg) weights

Method
1. Participant lies on their back, with their knees at right angles and feet flat on the floor.
2. The participant then attempts to perform one complete sit-up for each level in the prescribed manner (see norms below), starting with level 1.
3. Each level is achieved if a single sit-up is performed in the prescribed manner, *without the feet coming off the floor*. As many attempts as necessary can be made.

Results

<table>
<thead>
<tr>
<th>Level</th>
<th>Rating</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Very Poor</td>
<td>Cannot perform level 1</td>
</tr>
<tr>
<td>1</td>
<td>Poor</td>
<td>With arms extended, the athlete curls up so that the wrists reach the knees</td>
</tr>
<tr>
<td>2</td>
<td>Fair</td>
<td>With arms extended, the athlete curls up so that the elbows reach the knees</td>
</tr>
<tr>
<td>3</td>
<td>Average</td>
<td>With the arms held together across abdominals, the athlete curls up so that the chest touches the thighs</td>
</tr>
</tbody>
</table>
Muscular power tests

Muscular power is the ability to use strength quickly to produce an explosive movement. Chapter 8 explains that muscular power depends on strength and speed. It is central to actions in most sports where successful performance requires distance, height or any quick generation of force.

Most tests of muscular power measure either upper body power (arm, shoulder, chest and upper back muscles) or leg power (hip, thigh and calf muscles).

Basketball throw

Aim
To throw the ball as far as possible

Equipment
- Basketball
- Measuring tape
- Wall

Method
1. With back flush against the wall and legs fully extended, hold ball at chest height.
2. With arms only (back should stay against wall) push the ball out in front as far as you can.
3. Repeat three times with sufficient recovery (at least 1 minute) and record best score.
4. Some tests will include a hoop on the participant’s toes to ensure the ball is kept low and the movement isolates the arms and chest.

Results

**TABLES 9.14 AND 9.15 Basketball throw norms**

**Males**

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>High level of fitness in this area</th>
<th>Well above base standard</th>
<th>Above base standard</th>
<th>Below base standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>&lt;4.1</td>
<td>4.1–3.4</td>
<td>3.3–3.0</td>
<td>&gt;3.0</td>
</tr>
<tr>
<td>10</td>
<td>&lt;4.0</td>
<td>4.0–3.4</td>
<td>3.3–3.0</td>
<td>&gt;3.0</td>
</tr>
<tr>
<td>11</td>
<td>&lt;4.6</td>
<td>4.6–3.9</td>
<td>3.8–3.5</td>
<td>&gt;3.5</td>
</tr>
<tr>
<td>12</td>
<td>&lt;4.8</td>
<td>4.8–3.9</td>
<td>3.8–3.5</td>
<td>&gt;3.5</td>
</tr>
<tr>
<td>13</td>
<td>&lt;5.4</td>
<td>5.4–5.0</td>
<td>4.9–4.0</td>
<td>&gt;4.0</td>
</tr>
<tr>
<td>14</td>
<td>&lt;5.6</td>
<td>5.6–5.0</td>
<td>4.9–4.5</td>
<td>&gt;4.5</td>
</tr>
<tr>
<td>15</td>
<td>&lt;6.6</td>
<td>6.6–5.6</td>
<td>5.5–5.0</td>
<td>&gt;5.0</td>
</tr>
<tr>
<td>16</td>
<td>&lt;6.4</td>
<td>6.4–5.7</td>
<td>5.6–5.0</td>
<td>&gt;5.0</td>
</tr>
<tr>
<td>17</td>
<td>&lt;7.4</td>
<td>7.4–6.1</td>
<td>6.0–5.5</td>
<td>&gt;5.5</td>
</tr>
<tr>
<td>18</td>
<td>&lt;7.6</td>
<td>7.6–6.8</td>
<td>6.7–5.5</td>
<td>&gt;5.5</td>
</tr>
</tbody>
</table>

**Females**

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>High level of fitness in this area</th>
<th>Well above base standard</th>
<th>Above base standard</th>
<th>Below base standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>&lt;3.4</td>
<td>3.4–3.2</td>
<td>3.1–3.0</td>
<td>&gt;3.0</td>
</tr>
<tr>
<td>10</td>
<td>&lt;3.7</td>
<td>3.7–3.6</td>
<td>3.5–3.0</td>
<td>&gt;3.0</td>
</tr>
<tr>
<td>11</td>
<td>&lt;3.9</td>
<td>3.9–3.7</td>
<td>3.6–3.5</td>
<td>&gt;3.5</td>
</tr>
<tr>
<td>12</td>
<td>&lt;4.3</td>
<td>4.3–3.7</td>
<td>3.6–3.5</td>
<td>&gt;3.5</td>
</tr>
<tr>
<td>13</td>
<td>&lt;5.0</td>
<td>5.0–4.6</td>
<td>4.5–4.0</td>
<td>&gt;4.0</td>
</tr>
<tr>
<td>14</td>
<td>&lt;4.7</td>
<td>4.7–4.5</td>
<td>4.4–4.0</td>
<td>&gt;4.0</td>
</tr>
<tr>
<td>15</td>
<td>&lt;4.8</td>
<td>4.8–4.7</td>
<td>4.6–4.5</td>
<td>&gt;4.5</td>
</tr>
<tr>
<td>16</td>
<td>&lt;5.0</td>
<td>5.0–4.7</td>
<td>4.6–4.5</td>
<td>&gt;4.5</td>
</tr>
<tr>
<td>17</td>
<td>&lt;5.5</td>
<td>5.5–4.9</td>
<td>4.8–4.5</td>
<td>&gt;4.5</td>
</tr>
<tr>
<td>18</td>
<td>&lt;6.0</td>
<td>6.0–5.2</td>
<td>5.1–5.0</td>
<td>&gt;5.0</td>
</tr>
</tbody>
</table>

**FIGURE 9.16** Seated basketball throw test
Vertical jump

The vertical jump test, also referred to as the Sargeant jump test, is a test of leg power. It is easy to administer and has been used in test batteries for many years.

Aim
To jump as high as possible

Equipment
- Vertical jump board (recommended) or measuring tape attached to a wall
- Magnesium chalk

Method
1. The participant chalks the tips of their middle fingers with magnesium chalk.
2. The participant determines their standing height by fully extending arm overhead and recording the height reached (see figure 9.16a).
3. The participant stands side on to the jump board, takes a deep squat (see figure 9.16b) and springs as high as possible, touching the jump board with the hand and fingers closest to the board. They should keep their arm extended above their head so a chalk mark shows the height reached. Record this height.
4. The result calculated is the difference between the height reached on the jump and the initial standing height.
5. The participant rests for at least 3 minutes, then attempts a second trial.

Results
1. Record the best score obtained from the two trials. (Subtract standing height from jumped height.)
2. Refer to table 9.16 for ratings of leg power.

<table>
<thead>
<tr>
<th>TABLE 9.16 Ratings for the vertical jump test (centimetres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rating</td>
</tr>
<tr>
<td>-----------------</td>
</tr>
<tr>
<td>Excellent</td>
</tr>
<tr>
<td>Average</td>
</tr>
<tr>
<td>Fair</td>
</tr>
<tr>
<td>Poor</td>
</tr>
</tbody>
</table>

Norms
It is important to note that different sports will have different means and ranges for muscular leg power and the vertical jump. For example, the AIS has the following norms for particular sports at various levels.

<table>
<thead>
<tr>
<th>TABLE 9.17 AIS norms for the vertical jump test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sport</td>
</tr>
<tr>
<td>-------------------</td>
</tr>
<tr>
<td>Netball — national</td>
</tr>
<tr>
<td>AFL</td>
</tr>
<tr>
<td>Basketball — state</td>
</tr>
<tr>
<td>Basketball — state</td>
</tr>
<tr>
<td>Cricket — national</td>
</tr>
<tr>
<td>Cricket — national</td>
</tr>
</tbody>
</table>
9.5 Muscular strength, power and endurance tests

Standing long jump

The standing long-jump test is easily administered. It assesses the level of a participant’s leg muscle power (mainly the quadriceps and calf muscle groups).

Aim
To jump as far (horizontally) as possible

Equipment
- Tape measure
- Safe jumping area such as a sprung wooden floor, sandpit or fixed mat
- Gym shoes

Method
1. The participant stands behind a line with their feet shoulder width apart.
2. The participant bends their knees and swings their arms back and forth (see figure 9.18), jumping as far forward as possible and landing on both feet. Allow two trials with at least 3 minutes’ rest between each trial.
3. The score is the distance from the starting line to the point where the participant’s heel lands closest to the line.

Results
1. Record the best score obtained from the two trials.
2. Refer to table 9.18 for ratings of leg power.

TABLE 9.18 Ratings for the standing long-jump test (centimetres)

<table>
<thead>
<tr>
<th>Rating</th>
<th>Males aged 17 years</th>
<th>Males aged 18+ years</th>
<th>Females aged 17 years</th>
<th>Females aged 18+ years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>230 or more</td>
<td>239 or more</td>
<td>175 or more</td>
<td>180 or more</td>
</tr>
<tr>
<td>Fair</td>
<td>192–203</td>
<td>201–212</td>
<td>134–150</td>
<td>142–156</td>
</tr>
<tr>
<td>Poor</td>
<td>191 or less</td>
<td>200 or less</td>
<td>133 or less</td>
<td>141 or less</td>
</tr>
</tbody>
</table>

FIGURE 9.18 The standing long jump test
Magaria Kalamen power test

Power is a combination of strength and speed. These qualities are tested in the Magaria Kalamen power test.

**Aim**
To run up the steps as quickly as possible

**Equipment**
- Stopwatch
- Assistant
- Flight of 12 steps, with a run-up of 6 metres and the third, sixth and ninth steps emphasised.

**Method**
1. Measure and record the participant’s weight.
2. Measure the vertical distance between the third and ninth steps.
3. The participant sprints to and up the flight of steps, taking three steps at a time (third, sixth and ninth steps).
4. The assistant records the time taken to get from the third step to the ninth step (the stopwatch starts when the participant’s foot lands on the third step and stops when their foot lands on the ninth step).
5. Repeat this test three times, with 2–3 minutes’ recovery between trials.

**Results**
1. Record the best score obtained from the three trials.
2. Calculate the power using this equation:

   \[ P = \frac{9.8(M \times D)}{t} \]

   where:
   - \( P \) = power (watts)
   - \( M \) = body mass (kg)
   - \( D \) = vertical distance between steps 3 and 9 (m)
   - \( t \) = time (s)

**Muscular endurance tests**

Muscular endurance is the ability of a particular muscle or muscle group to continue working at the desired level of effort for as long as the situation demands (see chapter 8). Tests for muscular endurance will usually focus on one area of the body and therefore can readily be made specific for a particular sport’s requirements in the competitive situation. Most muscular endurance tests require the participant to complete the exercise for as long as they can or complete as many repetitions as they can in a set time, forcing the muscles/muscle group to work in the face of fatigue.
### 60-second push-up test

**Aim**
To complete as many pushups as you can to test the endurance of the upper body.

**Equipment**
- Flat surface

**Method**
Men should use the standard ‘military-style’ pushup position with only the hands and the toes touching the floor in the starting position.

Women have the additional option of using the ‘bent knee’ position.

1. To do this, kneel on the floor, hands on either side of the chest and keep your back straight.
2. Lower the chest down towards the floor, always to the same level each time, either till your elbows are at right angles or your chest touches the ground (see figure 9.18).
3. Do as many pushups as possible until exhaustion or 60 seconds is reached.
4. Count the total number of pushups performed.
5. Compare to relevant norms.

**Results**

**TABLE 9.19 Norms for 60-second pushup test**

<table>
<thead>
<tr>
<th></th>
<th>Age 17–19</th>
<th>20–29</th>
<th>30–39</th>
<th>40–49</th>
<th>50–59</th>
<th>60–65</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Men</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Excellent</td>
<td>&gt; 56</td>
<td>&gt; 47</td>
<td>&gt; 41</td>
<td>&gt; 34</td>
<td>&gt; 31</td>
<td>&gt; 30</td>
</tr>
<tr>
<td>Average</td>
<td>19–34</td>
<td>17–29</td>
<td>13–24</td>
<td>11–20</td>
<td>9–17</td>
<td>6–16</td>
</tr>
<tr>
<td>Below average</td>
<td>11–18</td>
<td>10–16</td>
<td>8–12</td>
<td>6–10</td>
<td>5–8</td>
<td>3–5</td>
</tr>
<tr>
<td>Poor</td>
<td>4–10</td>
<td>4–9</td>
<td>2–7</td>
<td>1–5</td>
<td>1–4</td>
<td>1–2</td>
</tr>
<tr>
<td>Very Poor</td>
<td>&lt; 4</td>
<td>&lt; 4</td>
<td>&lt; 2</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Age 17–19</th>
<th>20–29</th>
<th>30–39</th>
<th>40–49</th>
<th>50–59</th>
<th>60–65</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Women</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Excellent</td>
<td>&gt; 35</td>
<td>&gt; 36</td>
<td>&gt; 37</td>
<td>&gt; 37</td>
<td>&gt; 25</td>
<td>&gt; 23</td>
</tr>
<tr>
<td>Average</td>
<td>11–20</td>
<td>12–22</td>
<td>10–21</td>
<td>8–17</td>
<td>7–14</td>
<td>5–12</td>
</tr>
<tr>
<td>Below average</td>
<td>6–10</td>
<td>7–11</td>
<td>5–9</td>
<td>4–7</td>
<td>3–6</td>
<td>2–4</td>
</tr>
<tr>
<td>Poor</td>
<td>2–5</td>
<td>2–6</td>
<td>1–4</td>
<td>1–3</td>
<td>1–2</td>
<td>1</td>
</tr>
<tr>
<td>Very Poor</td>
<td>0–1</td>
<td>0–1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
30-second sit-up test

The maximum situps test is a basic item in many fitness test batteries, and it is designed to provide a measure of the endurance of the abdominal muscles. However, there are many variations of the test. Some have a time limit of 30 or 60 seconds, while others involve a predetermined number of repetitions.

The participant’s body position also varies with different formats of this test — using leg positions from slightly bent to fully flexed, and using arm positions from hands clasped behind the head (not recommended) to arms folded across the chest. The test outlined here is a standardised protocol for the maximum situps test performed with bent knees.

**Aim**
To complete as many repetitions as possible in the time permitted

**Equipment**
- Gym mat
- Stopwatch

**Method**
1. The participant lies on a mat with their knees flexed so the angle of their lower legs to their thighs is approximately 90 degrees. They place their arms across their chest, with each hand on the opposite shoulder (see figure 9.19(a)).
2. On the start command, the participant curls upwards and forwards, raising their body trunk until their elbows make contact with their thighs (see figure 9.19(b)). Then they return to the starting position.
3. The participant repeats this procedure as many times as possible within the 1-minute time limit.
4. A partner should count the number of correct situps completed and check for correct procedure.

**Results**
1. Record the number of situps completed within the time limit.
2. Compare the results with the ratings provided in table 9.20.
9.5 Muscular strength, power and endurance tests

### TABLE 9.20 Abdominal muscle endurance ratings (number of situps completed in 60 seconds)

<table>
<thead>
<tr>
<th>Rating</th>
<th>Males aged 15–19 years</th>
<th>Females aged 15–19 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>48 or more</td>
<td>42 or more</td>
</tr>
<tr>
<td>Good</td>
<td>42–47</td>
<td>36–41</td>
</tr>
<tr>
<td>Average</td>
<td>38–41</td>
<td>32–35</td>
</tr>
<tr>
<td>Fair</td>
<td>33–37</td>
<td>27–31</td>
</tr>
<tr>
<td>Poor</td>
<td>32 or fewer</td>
<td>26 or fewer</td>
</tr>
</tbody>
</table>

*Source: Adapted from Nieman 1993.*

### Curlup (crunch) test

A modification of the traditional situps test, the curlups test assesses endurance of the abdominal muscles. The aim is to complete as many curlups as possible at a rate of 20 per minute (up to a maximum of 60).

**Aim**

To complete as many repetitions as possible

**Equipment**

- Gym mat
- Cadence (or rate) audio recording

**Method**

1. The participant lies on the mat with their knees bent at a 90-degree angle, keeping their arms straight.
2. A partner kneels beside the participant and places a straight arm across the top of the participant’s knees, forming a ‘wall’.
3. Using the cadence audio recording, the participant curls up in time with the set rate. They must slide their hands along the top of their thighs until their hands touch the ‘wall’. The ‘up’ position must be held for 1 second. The participant then returns to the starting position.
4. The participant repeats the action until they complete 60 curlups. However, if they do not perform two consecutive curlups satisfactorily, they must withdraw from the test.

**Results**

1. Record the number of correctly completed curlups.
2. Refer to table 9.21 for the ratings for this test.
### Pullup/modified pullup test

Participants who are unable to complete one standard pullup can use the modified pullups test.

**Aim**
To complete as many repetitions as possible

**Equipment**
- An adjustable horizontal bar

**Method**
1. Set the bar at approximately the waist height of the participant.
2. The participant takes up the starting position, holding their body in a firm, straight position with their head, trunk, and legs in line and their heels on the floor.
3. From this extended position the participant pulls with their arms to raise their chest to the bar. Then they return to the starting position.
4. The participant repeats the action as many times as possible.

**Results**
1. Record the number of properly executed pullups.
2. Refer to table 9.22 for the ratings for this test.

### Flexed arm hang test

**Aim**
To hang with the chin above the bar as long as possible

**Equipment**
- Stopwatch
- Horizontal overhead bar at an adequate height
- Stool (optional)

**Method**
1. Participant grasps the overhead bar using an overhand grip (palms facing away from body), with the hands at shoulder width apart.

---

**TABLE 9.21 Ratings for the curlups test (number completed)**

<table>
<thead>
<tr>
<th>Rating</th>
<th>Males aged 17–18 years</th>
<th>Females aged 17–18 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>60</td>
<td>45–60</td>
</tr>
<tr>
<td>Good</td>
<td>60</td>
<td>32–44</td>
</tr>
<tr>
<td>Average</td>
<td>31–59</td>
<td>26–31</td>
</tr>
<tr>
<td>Fair</td>
<td>30</td>
<td>25</td>
</tr>
<tr>
<td>Poor</td>
<td>29 or fewer</td>
<td>24 or fewer</td>
</tr>
</tbody>
</table>

*Source: Adapted from Wright 1997.*

**TABLE 9.22 Ratings for the modified pullups test (number completed)**

<table>
<thead>
<tr>
<th>Rating</th>
<th>All persons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>23 or more</td>
</tr>
<tr>
<td>Good</td>
<td>19–22</td>
</tr>
<tr>
<td>Average</td>
<td>15–18</td>
</tr>
<tr>
<td>Fair</td>
<td>7–14</td>
</tr>
<tr>
<td>Poor</td>
<td>6 or less</td>
</tr>
</tbody>
</table>

*Source: Adapted from Sheriff 1991.*
9.5 Muscular strength, power and endurance tests

2. On the command ‘ready, go’, timing starts.
3. The participant should attempt to hold this position for as long as possible.

**Results**

**TABLE 9.23 Norms for the flexed arm hang test**

<table>
<thead>
<tr>
<th>Gender</th>
<th>Excellent</th>
<th>Above average</th>
<th>Average</th>
<th>Below average</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>&gt;13</td>
<td>9–13</td>
<td>6–8</td>
<td>3–5</td>
<td>&lt;3</td>
</tr>
<tr>
<td>Female</td>
<td>&gt;6</td>
<td>5–6</td>
<td>3–4</td>
<td>1–2</td>
<td>0</td>
</tr>
</tbody>
</table>

Table adapted from Davis et al. (2000)

**TEST your understanding**

1. Define the term *muscular strength*.
2. Define the term *muscular power*.
3. Define the term *muscular endurance*.
4. Describe the 1 RM bench press test.

**APPLY your understanding**

5. **Practical activity <description needed>**
   - (a) Complete as many muscular strength, power and endurance tests as you can.
   - (b) Compare your ratings for at least two muscular strength tests. Were they similar or different? Explain why this may be so.
   - (c) Compare your ratings for at least two muscular power tests. Were they similar or different? Explain why this may be so.
   - (d) Compare your ratings for at least two muscular endurance tests. Were they similar or different? Explain why this may be so.
   - (e) Describe each of the tests and identify one sport to which they may be suited.

6. **Identify and justify an appropriate muscular strength test for the following participants:**
   - (a) elite tennis player
   - (b) Year 12 class
   - (c) beginner at the gym

**EXAM practice**

7. Discuss, using specific examples, the differences between tests for muscular strength, power and endurance of the lower body. **6 marks**
9.6 Speed and agility tests

**KEY CONCEPT** Speed and agility tests require athletes to cover a set distance as quickly as possible. The difference between speed and agility tests is that agility tests require different movements or changes of direction.

**Speed**

Speed can refer to either whole-body speed — where the aim is to cover a specified distance in the shortest possible time — or part-body speed — where the aim is to move one or more parts of the body as quickly as possible to complete a movement (see chapter 8). Methods of assessing part-body speed are necessarily dependent on sophisticated recording methods, so most tests of speed centre on whole-body measurements.

Most tests of whole-body speed use distances of 5–50 metres. For testing of 5-metre, 10-metre and 20-metre distances, electronic timing gates are recommended to avoid human error.

**20-metre sprint test**

**Aim**
Run as quickly as possible for 20 m

**Equipment**
- Measuring tape or marked track
- Stopwatch or timing gates
- Cone markers

**Method**
1. Complete a standardised warm-up.
2. On ‘go’, start stopwatch and participant sprints 20 m.

**Results**

There are limited norms for the 20 m sprint, however the AIS have found the following mean values for Australian sportspeople.

<table>
<thead>
<tr>
<th>Sport</th>
<th>Sex</th>
<th>Age</th>
<th>Mean (seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Netball — national</td>
<td>Female</td>
<td>U17</td>
<td>3.52</td>
</tr>
<tr>
<td>AFL</td>
<td>Male</td>
<td>Approx. 18</td>
<td>3.04</td>
</tr>
<tr>
<td>Basketball — state</td>
<td>Female</td>
<td>U17</td>
<td>3.56</td>
</tr>
<tr>
<td>Basketball — state</td>
<td>Male</td>
<td>U17</td>
<td>3.24</td>
</tr>
<tr>
<td>Tennis — national</td>
<td>Female</td>
<td>16+</td>
<td>3.49</td>
</tr>
<tr>
<td>Tennis — national</td>
<td>Male</td>
<td>16+</td>
<td>3.09</td>
</tr>
</tbody>
</table>
9.6 Speed and agility tests

35-metre sprint test

Aim
Run as quickly as possible for 35 metres

Equipment
- Measuring tape or marked track
- Stopwatch or timing gates
- Cone markers

Method
1. Complete a standardised warm-up.
2. On ‘go’, start stopwatch and participant sprints 35 m.

Results

<table>
<thead>
<tr>
<th>Rating</th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very good</td>
<td>&lt; 4.80</td>
<td>&lt; 5.30</td>
</tr>
<tr>
<td>Good</td>
<td>4.80–5.09</td>
<td>5.30–5.59</td>
</tr>
<tr>
<td>Average</td>
<td>5.10–5.29</td>
<td>5.60–5.89</td>
</tr>
<tr>
<td>Fair</td>
<td>5.30–5.60</td>
<td>5.90–6.20</td>
</tr>
<tr>
<td>Poor</td>
<td>&gt; 5.60</td>
<td>&gt; 6.20</td>
</tr>
</tbody>
</table>

for Australian team sport players

50-metre sprint test

The 50-metre sprint test measures whole-body speed over a short distance.

Aim
To sprint as quickly as possible over 50 m

Equipment
- 50-metre marked course
- Stopwatch

Method
1. The participant warms up.
2. On the start command, the participant runs the 50-metre course as quickly as possible.
3. Record the time taken to cover the distance to the nearest one-hundredth of a second.
4. The participant completes two trials.
Agility tests

Agility is a combination of speed and flexibility and refers to the ability of a performer to change direction with maximal speed and control. It can be planned or unplanned (reaction) (see chapter 8).

Tests to assess this component of fitness generally involve running around and between obstacles (e.g. hats, chairs or cones) as quickly as possible. A number of recognised tests exist, but it is also possible to design tests that are specifically relevant to particular sports.

Illinois agility test

The Illinois agility test has been incorporated into test batteries for many years. It measures the ability to quickly change direction without losing control or balance.

Aim
To complete course, changing direction and moving around cones, as quickly as possible

Equipment
- Six chairs or cones
- Tape measure
- Stopwatch

Method
1. Set up the course as shown in figure 9.22.
2. The participant lies on their stomach with their hands beside their chest and their forehead on the starting line.
3. On the start command, the participant jumps up and completes the course as quickly as possible. One foot must touch the end line.
4. Record how long it takes the participant to complete the course.
5. Run two trials if necessary (so the participant has some practice).
### Results

1. Record the best time taken to complete the course to the nearest tenth of a second.
2. Compare results with the ratings shown in table 9.27.

### TABLE 9.27 Ratings for the Illinois agility test (seconds)

<table>
<thead>
<tr>
<th>Rating</th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>Under 15.9</td>
<td>Under 17.5</td>
</tr>
<tr>
<td>Good</td>
<td>15.9–16.7</td>
<td>17.5–18.6</td>
</tr>
<tr>
<td>Average</td>
<td>16.8–18.6</td>
<td>18.7–22.3</td>
</tr>
<tr>
<td>Fair</td>
<td>18.7–18.8</td>
<td>22.4–23.4</td>
</tr>
<tr>
<td>Poor</td>
<td>18.9 or over</td>
<td>23.5 or over</td>
</tr>
</tbody>
</table>

**Source:** Adapted from Schell & Leelarthaepin 1994.
Semo agility test

The Semo agility test assesses the agility of a participant in manoeuvring forwards, backwards and sideways. It is particularly well suited to sports such as tennis, volleyball, badminton and basketball.

Aim
To complete course, using a variety of movements (sprinting, running backwards and side-stepping) moving around cones, as quickly as possible

Equipment
- Four cones or chairs
- Stopwatch
- Tape measure

Method
1. Set up the course as shown in figure 9.23.
2. The participant completes the course, beginning at point A with their back to the square.
3. The participant always faces the same direction, therefore requiring sideways, backwards and forwards locomotion.
4. Allow at least one practice trial and two re-trials.

Results
1. Record the best time taken to complete the course to the nearest tenth of a second.
2. Compare results with the ratings shown in table 9.28.

**TABLE 9.28 Ratings for the Semo agility test (seconds)**

<table>
<thead>
<tr>
<th>Rating</th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>Under 10.7</td>
<td>Under 12.19</td>
</tr>
<tr>
<td>Good</td>
<td>11.49–10.7</td>
<td>12.99–12.19</td>
</tr>
<tr>
<td>Average</td>
<td>13.02–11.50</td>
<td>13.90–13.00</td>
</tr>
<tr>
<td>Fair</td>
<td>13.79–13.03</td>
<td>14.49–13.91</td>
</tr>
<tr>
<td>Poor</td>
<td>13.80 or over</td>
<td>14.50 or over</td>
</tr>
</tbody>
</table>

*Source: Adapted from Malpeli, R, Horton, M & Davey, G 1994, Physical education, VCE Units 3 and 4, Thomas Nelson, South Melbourne.*
5-0-5 agility test

**Aim**
To sprint, change direction and sprint back as quickly as possible

**Equipment**
- Start/stop timing gates or stopwatch
- Non-slip running surface
- Cone markers

**Method**
1. Set up markers 5 and 15 metres from a line marked on the ground (see figure 9.22).
2. The participant sprints from the 15-metre marker towards the line (run in distance to build up speed) and through the 5-metre markers, turns on the line and runs back through the 5-metre markers.
3. The time is recorded from when the participant first runs through the 5-metre markers, and stopped when they return through these markers (that is, the time taken to cover the 5 m up and back distance — 10 m total).
4. Repeat after at least 3 minutes passive recovery. The best of two trials is recorded.
5. The turning ability on each leg should be tested. The participant should be encouraged to not overstep the line by too much, as this will increase their time.
Results
There are limited norms for the 5-0-5 agility test however the AIS have found the following mean values for Australian sportspeople.

TABLE 9.29 5-0-5 agility test norms

<table>
<thead>
<tr>
<th>Sport</th>
<th>Sex</th>
<th>Age</th>
<th>Mean left foot (seconds)</th>
<th>Mean right foot (seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cricket — national</td>
<td>Female</td>
<td>open</td>
<td>2.49</td>
<td>2.45</td>
</tr>
<tr>
<td>Cricket — national</td>
<td>Male</td>
<td>U19</td>
<td>2.27</td>
<td>2.28</td>
</tr>
<tr>
<td>Rugby — elite</td>
<td>Male</td>
<td>U19</td>
<td>2.30</td>
<td>n/a</td>
</tr>
<tr>
<td>Tennis — national</td>
<td>Female</td>
<td>16+</td>
<td>2.48</td>
<td>2.49</td>
</tr>
<tr>
<td>Tennis — national</td>
<td>Male</td>
<td>16+</td>
<td>2.33</td>
<td>2.33</td>
</tr>
</tbody>
</table>

TEST your understanding
1 Define the term speed.
2 Define the term agility.
3 Outline the main differences between the three agility tests.

APPLY your understanding
4 Practical activity <description needed>
   (a) Complete as many speed and agility tests as you can.
   (b) Compare your ratings for at least two speed tests. Were they similar or different? Explain why this may be so.
   (c) Compare your ratings for at least two agility tests. Were they similar or different? Explain why this may be so.
   (d) Describe each of the tests and identify one sport to which they may be suited.
5 Identify and justify an appropriate agility test for the following participants:
   a) elite rugby player
   b) Year 12 class
   c) beginner at the gym

EXAM practice
6 Identify and justify which recognised agility test would be most appropriate for a squash player. 3 marks
9.7 Flexibility and body composition tests

**KEY CONCEPT** There are a range of flexibility and body composition tests. They differ significantly in terms of practicality and accuracy.

**Body composition tests**

Body composition refers to the relative proportions of bone, muscle and fat within the body. Assessment measures range from sophisticated, individualised and expensive measures such as hydrodensitometry, to measures that are less accurate but more available and accessible for larger numbers, such as body mass index.

The ‘gold standard’ test for body composition is underwater weighing. This is a sophisticated process that requires specialist, expensive equipment and complex calculations, however it is believed to be the most accurate measure. This is used for those with invested interest in body composition and generally not used by the general public. Body mass index is more likely to be used by the general public. While it is not very accurate, it provides a helpful guide for body composition.

It is important to note that body composition tests are often used in assessing the health of an individual as body composition can give an indication of obesity.

**Body mass index (BMI)**

The body mass index is used to assess weight relative to height.

**Aim**
To assess weight relative to height

**Equipment**
- Weight scales
- Height scale or measuring tape

**Method**
1. Weigh the participant when they are wearing minimal clothing.
2. Measure the height of the participant when they are not wearing shoes.

**Results**
1. Calculate the participant’s body mass index using the following formula:

\[
\text{BMI} = \frac{\text{Weight (kilograms)}}{\text{Height (metres)}^2}
\]

2. Refer to table 9.30 for the relevant classifications.

**TABLE 9.30 General BMI ratings for males and females**

<table>
<thead>
<tr>
<th>Rating</th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underweight</td>
<td>19 or less</td>
<td>18 or less</td>
</tr>
<tr>
<td>Acceptable weight range</td>
<td>20–25</td>
<td>19–24</td>
</tr>
<tr>
<td>Overweight</td>
<td>26–30</td>
<td>25–30</td>
</tr>
<tr>
<td>Obese</td>
<td>31 or more</td>
<td>31 or more</td>
</tr>
</tbody>
</table>
Waist circumference

Aim
To measure around the waist

Equipment
- Tape measure

Method
1. Find the top of your hip bone and the bottom of your ribs.
2. Breathe out normally.
3. Place the tape measure midway between these points and wrap it around your waist.
4. Check your measurement.

Results

<table>
<thead>
<tr>
<th>Table 9.31 Norms for healthy waist measurement, men and women</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Your health is at risk if your waist size is:</strong></td>
</tr>
<tr>
<td>Men</td>
</tr>
<tr>
<td>Women</td>
</tr>
</tbody>
</table>

These guidelines are based on World Health Organization and National Health and Medical Research Council recommendations.

Skinfold measurements

Skinfold measurement is the most widely used measure for determining body composition, and specifically body fat percentage. Skinfolds can be measured at several specific sites, the more common being the abdomen, calf, subscapula, suprailiac, thigh and triceps. Testers can use many different combinations of skinfold site measurements to predict percentage body fat. The two-site skinfold test, using the triceps and subscapula sites, has been the most commonly used test for young people aged 6–17 years.

Equipment
- Skinfold calipers (e.g. Harpenden, Fat-o-meter)

Method
1. Locate and mark the following skinfold sites on the right-hand side of the participant's body:
   (a) triceps — the back of the upper arm midway between the shoulder and elbow joints (see figure 9.23)
   (b) subscapula — just below the lowest point of the scapular or shoulder blade.
2. Pick up the skinfold between the thumb and forefinger about 1 centimetre above the marked site. The skinfold should include skin and subcutaneous fat but not muscle.
3. Apply the calipers to the marked location, slowly releasing the pressure on the caliper trigger so the pinchers exert full tension on the skinfold.
9.7 Flexibility and body composition tests

4. When the pointer on the dial steadies, take the measurement in tenths of a millimetre.
5. To ensure accuracy, take three readings at each site. Record the median score.

**FIGURE 9.24** Skinfold measurement test using the tricep.

**FIGURE 9.25** The sites for skinfold measurements

**Results**
1. Add the two median scores for the two sites to give a skinfolds total.
2. Refer to figure 9.25 to obtain the predicted percentage body fat and body fat standards.
Hydrodensitometry (underwater) weighing

**Aim**
To measure the density of the body in order to then calculate the percentage of body fat

**Equipment**
- Hydrostatic stainless steel weighing tank, including underwater mounted chair and scale
- Weighted belt
- Nose clip
- A simpler set-up may include a chair and scale suspended from a diving board over a pool or hot tub.

**Method**
1. The dry weight of the subject is first determined. The subject, in minimal clothing, then sits on a specialised seat, expels all the air from their lungs, and is lowered into the tank until all body parts are submerged.
2. Underwater weight is recorded.
3. This procedure is repeated several times to get a dependable underwater weight measure.

**Results**

\[
\text{Body density} = \frac{W_a}{(W_a - W_w) / D_w} - (RV + 100cc)
\]

where \(W_a\) = body weight in air (kg), \(W_w\) = body weight in water (kg), \(D_w\) = density of water, \(RV\) = residual lung volume and 100cc is the correction for air trapped in the gastrointestinal tract. The body density (\(D\)) can be converted to percent body fat (\(\%BF\)) using the Siri equation.

**FIGURE 9.26** Predicted percentage body fat and body fat standards using triceps and subscapula skinfold sites for 6–17 year olds

*Source:* Adapted from *Journal of Physical Education, Recreation and Dance*, vol. 58, no. 9, p. 99.
9.7 Flexibility and body composition tests

Bioelectrical impedance

Aim
The proportion of body fat can be calculated as the current flows more easily through the parts of the body that are composed mostly of water (such as blood, urine and muscle) than it does through bone, fat or air. It is possible to predict how much body fat a person has by combining the bioelectric impedance measure with other factors such as height, weight, gender, fitness level and age.

Equipment
- A bioelectric impedance analyser is a sophisticated scientific instrument OR many bathroom weighing scales are also available with a bioelectric impedance analyser.

Method
1. Stand on the analyser. Participant should not be in contact with any other non-conducting surface, with legs apart and arms away from the body.
2. Some devices require a pair of electrodes are placed on the hand and wrist, and another pair placed on the ankle and foot (usually opposite sides of the body).
3. Follow the instructions of your particular device.

Results
See skinfolds and % body fat norms.

DEXA and TOBEC scans

Aim
DEXA: Uses a whole body scanner that has two low dose x-rays at different sources, which simultaneously read bone and soft tissue mass. This technique is based on the assumption that bone mineral content is directly proportional to the amount of photon energy absorbed by the bone being studied.

TOBEC: This method is based on lean tissue being a better conductor of electricity than fat.

Equipment
- DEXA specialised X-ray
- TOBEC machine

Method
DEXA
1. Participant lies down on x-ray table. The sources are mounted beneath a table with a detector overhead.
2. Participant must lie still throughout the procedure.
3. The scanner passes across the person’s reclining body, with data collected at 0.5 cm intervals. A scan takes between 10 and 20 minutes.
TOBEC
1. Participant lies in a cylinder that generates a very weak electromagnetic field.
2. The strength of the field depends on the electrolytes found in the person’s body water. In about 10 seconds, TOBEC makes 10 conductivity readings that estimate lean body mass.

Results
See skinfolds and % body fat norms.

Flexibility tests
Flexibility may be dynamic or static. Most tests of flexibility measure static flexibility because dynamic flexibility tests are difficult to implement.

Flexibility testing requires careful monitoring of safety measures. The participant should be thoroughly warmed up before attempting carefully monitored maximal stretches — it is essential that a full and measurable total body warm-up is carried out beforehand. This is to ensure a full range of movement is safely possible at a particular joint or sequence of joints. Safety is paramount in these tests.

Trunk flexion (sit-and-reach) test
The sit-and-reach test has been a standard assessment in most fitness test batteries for many years. However, there are variations in the method and scoring of this test. The following protocol is for the modified sit-and-reach test, which measures the flexibility of the hamstrings and lower back.
9.7 Flexibility and body composition tests

**Aim**
To reach forward as far as you can

**Equipment**
- Sit-and-reach box (recommended) or bench and ruler

**Method**
1. Sit on the floor with legs stretched out straight ahead. Shoes should be removed.
2. The soles of the feet are placed flat against the box/bench. Both knees should be locked and pressed flat to the floor — the tester may assist by holding them down.
3. With the palms facing downwards, and the hands on top of each other or side by side, the subject reaches forward along the measuring line as far as possible. Ensure that the hands remain at the same level, not one reaching further forward than the other.
4. After some practice reaches, the subject reaches out and holds that position for at least one or two seconds while the distance is recorded. Make sure there are no jerky movements.

**Results**
1. Record the best score measured in centimetres to the nearest half-centimetre.
2. Refer to table 9.32 for ratings for this test.

**TABLE 9.32 Ratings for the modified sit-and-reach test (centimetres)**

<table>
<thead>
<tr>
<th>Rating</th>
<th>Males aged 17 years</th>
<th>Males aged 18 years</th>
<th>Females aged 17 years</th>
<th>Females aged 18 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left leg</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Greatly above base standard</td>
<td>33 or more</td>
<td>35 or more</td>
<td>35 or more</td>
<td>39 or more</td>
</tr>
<tr>
<td>Below base standard</td>
<td>21 or less</td>
<td>21 or less</td>
<td>23 or less</td>
<td>23 or less</td>
</tr>
<tr>
<td>Right leg</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Greatly above base standard</td>
<td>34 or more</td>
<td>37 or more</td>
<td>36 or more</td>
<td>38 or more</td>
</tr>
<tr>
<td>Below base standard</td>
<td>21 or less</td>
<td>21 or less</td>
<td>23 or less</td>
<td>23 or less</td>
</tr>
</tbody>
</table>

*Source:* Adapted from Wright 1997.
Trunk rotation test

Aim
To reach as far as you can each side

Equipment
- Wall
- A piece of chalk or pencil
- Ruler or tape measure

Method
1. On a wall, mark a line (vertical). Stand with your back facing the wall, about an arm’s length away from the wall, directly in front of the line, with your feet shoulder-width apart.
2. Extend your arms out directly in front of you, parallel to the floor.
3. Twist to your right and touch the wall behind you with your fingertips (arms extended and parallel to the floor). Feet cannot move.
4. Mark where your fingertips touched the wall, and measure the distance in centimetres from the line. A point before the line is a negative score and a point after the line is a positive score.
5. Repeat for the left side with your feet in the same position.

Results

<table>
<thead>
<tr>
<th>Rating</th>
<th>Score (cms)</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Very good</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Good</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Fair</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Poor</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>
9.7 Flexibility and body composition tests

Groin flexibility test

Aim
To let your knees drop as close to the ground as possible

Equipment
- Ruler or tape measure

Method
1. Sit on the floor with your knees bent, and your feet flat on the floor and legs together.
2. Let your knees drop down to the ground as far as possible keeping your feet together.
3. Hold on to your ankles with both hands, and pull them as close to your body as possible.
4. Measure the distance from your heels to your groin.

Results

<table>
<thead>
<tr>
<th>Rating</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>5 cm</td>
</tr>
<tr>
<td>Very good</td>
<td>10 cm</td>
</tr>
<tr>
<td>Good</td>
<td>15 cm</td>
</tr>
<tr>
<td>Fair</td>
<td>20 cm</td>
</tr>
<tr>
<td>Poor</td>
<td>25 cm</td>
</tr>
</tbody>
</table>

Shoulder and wrist elevation test

The shoulder elevation test measures the flexibility of the shoulder joint. It is sometimes referred to as the shoulder hyper-extension test.

Aim
To reach as high as possible

Equipment
- 2-metre rulers
- Tape measure

Method
1. Use the tape measure to determine the length of the participant’s arm from their acromial process to their fingertips.
2. The participant lies on the floor with their arms fully extended overhead. They grasp one ruler with their hands shoulder-width apart.
3. The participant raises the ruler as high as possible while keeping their chin on the floor. Read the measurement off the other ruler, which is held vertical (see figure 9.28).
Results
1. Calculate the score obtained by subtracting the measurement of the height reached from the participant’s arm length. Record this score.
2. Refer to table 9.35 for the ratings for the shoulder elevation test.

**TABLE 9.35 Ratings for the shoulder elevation test (centimetres)**

<table>
<thead>
<tr>
<th>Rating</th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>14 or less</td>
<td>13 or less</td>
</tr>
<tr>
<td>Good</td>
<td>15–19</td>
<td>14–19</td>
</tr>
<tr>
<td>Average</td>
<td>20–29</td>
<td>20–27</td>
</tr>
<tr>
<td>Fair</td>
<td>30–32</td>
<td>28–30</td>
</tr>
<tr>
<td>Poor</td>
<td>33 or more</td>
<td>31 or more</td>
</tr>
</tbody>
</table>

*Source:* Adapted from Malpeli, Horton & Davey 1997.

**FIGURES 9.29** The shoulder and wrist elevation test

**Trunk and neck extension test**

The static flexibility test (trunk and neck) is a measure of the static flexibility of the trunk and neck.

**Aim**
To lift head as high as possible

**Equipment**
- Ruler or measuring tape
- Assistant
9.7 Flexibility and body composition tests

**Method**

1. The participant lays prone on the floor with their hands clasped at the side of their head.
2. They raise their trunk as high as possible while still keeping their hips in contact with the floor.
3. Record the height from the tip of their nose to the floor.
4. Repeat the test three times.

**Results**

1. Select the best recorded height.
2. Refer to table 9.36 for the ratings for this test.

**TABLE 9.36 Normative results for the static flexibility test (trunk and neck)**

<table>
<thead>
<tr>
<th>Rating</th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>&gt; 25</td>
<td>&gt; 24.8</td>
</tr>
<tr>
<td>Good</td>
<td>25.0–20.3</td>
<td>24.7–19.7</td>
</tr>
<tr>
<td>Average</td>
<td>20.2–15.2</td>
<td>19.6–14.6</td>
</tr>
<tr>
<td>Fair</td>
<td>15.1–7.6</td>
<td>14.5–5.1</td>
</tr>
<tr>
<td>Poor</td>
<td>&lt; 7.6</td>
<td>&lt; 5.1</td>
</tr>
</tbody>
</table>

*Source: Adapted from Johnson, BL & Nelson, JK 1986, Practical measurements for evaluation in PE, 4th edn.*

**Ankle extension/dorsiflexion test**

The Ankle extension/dorsiflexion test is a measure of the static flexibility of the ankle.

**Aim**

To stretch feet back towards body as much as possible

**Equipment**

- Ruler or measuring tape
- Assistant

**Method**

1. The participant stands facing a wall with their feet flat on the ground and their toes touching the wall.
2. They lean into the wall.
3. The participant slowly slides their feet back from the wall as far as possible, keeping their feet flat, knees fully extended and chest touching the wall.
4. Measure the distance between the front of the participant’s toes and the base of the wall.
5. Repeat the test three times.

**Results**

Refer to table 9.37 for the ratings for this test.
TABLE 9.37 Normative results for the static flexibility test (ankle)

<table>
<thead>
<tr>
<th>Rating</th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>&gt; 88.89</td>
<td>&gt; 81.27</td>
</tr>
<tr>
<td>Good</td>
<td>88.89–82.55</td>
<td>81.27–77.47</td>
</tr>
<tr>
<td>Average</td>
<td>82.54–74.93</td>
<td>77.46–67.31</td>
</tr>
<tr>
<td>Fair</td>
<td>74.92–67.31</td>
<td>67.30–61.60</td>
</tr>
<tr>
<td>Poor</td>
<td>&lt; 67.31</td>
<td>&lt; 61.60</td>
</tr>
</tbody>
</table>

Source: Adapted from Johnson, BL & Nelson, JK 1996, Practical measurements for evaluation in PE, 4th edn.

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Shoulder rotation test

Aim
To move a ruler over your head with the shortest distance between your hands

Equipment
- Stick or towel
- Ruler or tape measure

Method
1. Hold a towel or a stick in front of the body with both hands wide apart and palms facing downwards.
2. Maintaining the hand grip on the object, lift the stick over the head to behind the back.
3. Repeat the test, moving hands closer together each time until the movement cannot be completed.
   Alternatively, if your hands can slide along the stick or ruler, start with the hands close together, and as you swing the object over your head, slowly slide the hands apart just enough to enable it to go over your head and behind you.
4. Repeat a few times.
5. Measure the minimum distance between the hands.

Results

TABLE 9.38 Shoulder rotation test norms

<table>
<thead>
<tr>
<th>Rating</th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>&lt; 7.00</td>
<td>&lt; 5.00</td>
</tr>
<tr>
<td>Good</td>
<td>7.00–11.50</td>
<td>5.00–9.75</td>
</tr>
<tr>
<td>Average</td>
<td>11.51–14.50</td>
<td>9.76–13.09</td>
</tr>
<tr>
<td>Fair</td>
<td>14.51–19.75</td>
<td>13.10–17.75</td>
</tr>
<tr>
<td>Poor</td>
<td>&gt; 19.75</td>
<td>&gt; 17.75</td>
</tr>
</tbody>
</table>

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9.7 Flexibility and body composition tests

TEST your understanding
1 Define the term flexibility.
2 Define the term body composition.
3 List the main characteristics of reliable flexibility tests.
4 Rank the body composition tests from most accurate to least accurate.
5 Describe what is meant by a ‘gold standard’ test.

APPLY your understanding
6 Practical activity
   (a) Complete as many body composition and flexibility tests as you can.
   (b) Compare your ratings for at least two body composition tests. Were they similar or different? Explain why this may be so.
   (c) Compare your ratings for at least two flexibility tests. Were they similar or different? Explain why this may be so.
   (d) Describe each of the tests and identify one sport to which they might be suited.

7 Identify and justify an appropriate flexibility test for the following participants:
   - elite badminton player
   - Year 12 class
   - beginner at the gym.

EXAM practice
8 Discuss the relationship between practicality and accuracy of body composition tests using specific examples.

9 For the shoulder and wrist elevation and sit and reach tests, identify and justify a participant who is likely to use it, as it replicates their flexibility requirements.
KEY SKILLS

Determine an appropriate fitness testing regime based on the physiological, psychological and sociocultural needs of the individual and the requirements of the activity.

Conduct a valid and reliable assessment of fitness using ethical protocols.

Perform, observe, analyse and report on practical laboratory exercises designed to assess fitness prior to designing a training program.

Justify the selection of fitness tests in relation to the physiological, psychological and sociocultural requirements of the test subject.

UNDERSTANDING THE KEY SKILLS

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

When choosing a test, the following should be considered: replicating the requirements of the sport, the physiological state (PAR-Q), psychological state and sociocultural needs of the subject.

Recognised and standardised tests are more likely to be accurate and comparable to norms.

PRACTICE QUESTIONS

1. Justify the use of a VO₂ max test for an Olympic marathon runner. (2 marks)

2. Outline two procedures that will increase the accuracy and reliability of pre- and post-fitness testing. (2 marks)

SAMPLE RESPONSE

1. The VO₂ max test is a maximal laboratory test, which is expensive but very accurate as it is individualised. It is a direct test which an Olympic marathon runner would require and be willing to pay for.

2. The tests are completed using the same equipment each time and the participant completes the same warm-up prior to the test each time. OR, a different response could be:

   1. Exhaustive, expensive, highly accurate, individualised, direct
   2. They are completed using the same equipment. They are completed with the same pre-test conditions (warm-up, nutrition). The same testing protocols are followed.

STRATEGIES TO DECODE THE QUESTION

1. Identify the action words:
   - Justify — explain why the option you chose is the best option
   - Outline — general description but not in detail

2. Key terminology:
   - VO₂ max. test — exhaustive, expensive, highly accurate, individualised
   - Accuracy and reliability — only one variable, the participant should change

3. Key concepts:
   - Olympic marathon runner — elite, individual, high aerobic power
   - Procedures — equipment, preparation, recording, environment

Marking scheme:

1. 2 marks for outlining each of two procedures
2. 2 marks — always check marking scheme for depth of response required, linking to key information highlighted in the question

HOW THE MARKS ARE AWARDED

- 1 mark: for each of two reasons
- 1 mark: for outlining each of two procedures
CHAPTER REVIEW  FITNESS TESTING: RATIONALE AND TESTS

CHAPTER SUMMARY

- Fitness testing is integral to any serious fitness training program and to any participant and should be completed after activity analysis.
- Fitness assessment provides a measurement of physiological responses to physical activity within a controlled environment.
- Sophisticated laboratory tests or simpler field tests can be used to assess fitness levels.
- Participants can undergo fitness testing before, during and after a training program. Testing can identify specific attributes of the participant, determining the participant’s strengths and weaknesses, monitoring progress and providing motivation.
- Pre-participation health screening (PAR-Q) and informed consent are an important part of the testing process.
- There are clear testing protocols that should be put in place to ensure safety and ultimate test reliability and validity.
- A wide variety of tests is available to assess fitness levels.

EXAM PREPARATION

MULTIPLE CHOICE QUESTIONS

1. Which of the following is a maximal test for aerobic capacity?
   (A) 20-m shuttle run
   (B) Yo-yo test
   (C) Cooper 12-min run
   (D) VO$_2$ max. treadmill test

2. Which of the following tests does not require the participant to run as long as they can?
   (A) 20-m shuttle run
   (B) Yo-yo test
   (C) Cooper 12-min run
   (D) VO$_2$ max. treadmill test

3. The cycling track sprint ranges from 600 m to 1000 m. An athlete who scores highly in which test would be best suited to this event?
   (A) Phosphate recovery test
   (B) Wingate cycling test
   (C) VO$_2$ max. cycle test
   (D) Squat test

4. Which test requires the participant to complete as many repetitions as possible?
   (A) Flexed arm hang test
   (B) 1 RM squat
   (C) 3 RM bench press
   (D) 60-second push-up test

5. Pre-training program testing does not
   (A) motivate athletes.
   (B) set benchmarks.
   (C) identify strengths and weaknesses.
   (D) identify predominant muscle groups and energy systems required for activity.

6. Which of the following shows the correct order of tests to ensure the most accurate results?
   (A) Least to most fatiguing
   (B) Most to least fatiguing
   (C) Aerobic tests first then anaerobic tests, as the aerobic tests act as a warm-up
   (D) B and C

7. To ensure reliability of tests when comparing a number of participants on the same fitness component, what should be the only variable that changes between tests?
   (A) The participant
   (B) The test, as long as it still tests the same fitness component
   (C) When the testing is held
   (D) The norms used
8 Post-season testing
(A) should not be done unless the athlete is elite.
(B) should use the same tests as used in any pre- or in-season testing.
(C) can use different tests but must test the same fitness components and energy systems.
(D) is a waste of time as the season is finished.

9 Which of the following is the most accurate method of testing body composition?
(A) BMI
(B) Waist circumference
(C) DEXA scan
(D) Hydrodensitometry (underwater) weighing

10 If an 18-year-old male scored 58 cm on the vertical jump, it would be considered
(A) excellent.
(B) good.
(C) fair.
(D) poor.

TRIAL EXAM QUESTIONS

Question 1
(ACHPER Trial Exam 2015, question 7)
Body composition tests are designed to assess the proportion of body fat compared to lean tissue in an individual. Two recognised body composition tests are body mass index (BMI) and sum of skin folds. Evaluate the differences between these two tests and suggest the most appropriate test to be used by elite participants.

3 marks

Question 2
(ACHPER Trial Exam 2013, question 9c)
Flexibility decreases as we age. What are two other factors that affect flexibility? Provide an explanation as to how each factor affects this fitness component.

4 marks