Tennis Australia

National Physical Performance Protocols
**Population:** our nation’s best tennis players.

**Intention:** to evaluate specific aspects of a player’s physical condition.

**Background:** an appropriate battery of fitness tests is both valid and reliable, and thus helps assess the foremost physical attributes that contribute to a player’s successful tennis performance.

<table>
<thead>
<tr>
<th><strong>ANTHROPOMETRY</strong></th>
<th>Height</th>
<th>Mass</th>
<th>Girths</th>
<th>Sum of seven skinfolds</th>
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<tbody>
<tr>
<td><strong>FLEXIBILITY</strong></td>
<td>Completed in musculoskeletal screening</td>
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<tr>
<td><strong>SPEED</strong></td>
<td>20 metre sprint (5 m and 10 m splits)</td>
<td>Best 5, 10 and 20 m times.</td>
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<tr>
<td><strong>AGILITY/COORDINATION</strong></td>
<td>505</td>
<td>Modified 505</td>
<td>Best times, and 505:10 m ratio</td>
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<tr>
<td><strong>LEG POWER</strong></td>
<td>CMJ jumps</td>
<td>Maximum height</td>
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<tr>
<td>**STRENGTH * **</td>
<td>Push - ups</td>
<td>Chin - ups</td>
<td>3RM bench press</td>
<td>3RM bench pull</td>
<td>3RM squat</td>
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<tr>
<td><strong>REPEAT SPEED ABILITY</strong></td>
<td>10 x 20 m maximum sprint</td>
<td>Best time, total time, % decrement</td>
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<tr>
<td><strong>AEROBIC ENDURANCE</strong></td>
<td>Multistage fitness (beep) test</td>
<td>Level (est.VO2 max)</td>
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</table>

*Maximal strength testing is used at the discretion of the physical performance coach.*
**Conditions/environment**

- Most tests are effort dependent so for valid results, players must perform maximally.
- Players will be required to present to each testing session in a rested state, having refrained from the ingestion of caffeine and a large amount of food in the two hours prior to testing.
- Players should complete a standardised warm-up prior to their participation in the dynamic/movement tests (i.e., once their anthropometry has been measured).
- Where possible, the tests should be carried out at the same time of day (± one hour), and in the same order (see Test Order) during each testing session.
- Testing should not be conducted in extreme environmental conditions, particularly when very hot and humid. While it is not always possible to control the environmental conditions for field testing, testing can be performed at times of the day where the conditions are at their least extreme. The time of day, temperature (°C) and humidity (%) should be recorded.
- Verbal encouragement should be given to the players throughout the tests.
- Upon completion of the testing battery, selected tests or testing days, players should be encouraged to warm down.

**Test order**

The tests need to be completed in the same order to minimise interference between tests and therefore the misinterpretation of results. This also allows for valid comparison of different test occasions. Where practically possible, the order should be as follows:

**Day 1**

i. Anthropometry  
ii. 20 m sprints  
iii. 505 agility test  
iv. Counter movement jumps  
v. 10 x 20 m repeated sprint ability (RSA) test  
vi. Multistage fitness test

**Day 2**

vii. Strength tests

This is a general guide to the order of testing and may differ when working with groups. However, it is important that the first (anthropometry) and last two tests (RSA and multistage fitness tests) are conducted in the order listed.

A minimum of 30–60 seconds of rest should be provided to players between different trials of the same (speed, agility and power) test. Suitable recovery, in the order of approximately ≥3 minutes rest, should also be allocated between tests. Obvious exceptions include the strength tests that tax the same body parts as well as the RSA and multistage fitness test protocols, whose performance would ideally be separated by ≥30 minutes.

**Test performance**

As mentioned above, maximal effort is expected and should be encouraged. Generally, the more often that players perform tests, the more comfortable that they will become. This is an important consideration when administering tests, and then, interpreting test results. In an effort to minimise the effect of learning, players should be given the opportunity to practice each test at least once before/during the testing session. In certain circumstances (i.e., where following three practices players still experience difficulty in successfully rehearsing the test), a test may need to be rescheduled and/or the recommendation given that the player not perform the test on this occasion but become more familiar with it prior to the next testing session.
Tennis requires great agility and speed. It is often played in hot, humid conditions; and a player with excess adipose tissue may be predisposed to heat strain and/or premature fatigue. In order to achieve maximum health and performance, tennis players require an optimal body composition.

**Test procedures/measurements:**
The anthropometric measurements of stretch height, mass, girths and sum of seven skinfolds are taken in accordance with Tennis Australia’s anthropometry position stand. They should be performed by an accredited anthropometry specialist.

- **Height** – measured in centimetres.
- **Mass** – measured in kilograms.
- **Body composition** – girths and skinfolds.

**Girths**

- **Arm relaxed**: The circumference of the arm at the level of the Mid-acromiale-radiale® site, perpendicular to the long axis of the arm.

- **Arm flexed and tensed**: The circumference of the arm perpendicular to the long axis of the arm at the level of the peak of the contracted Biceps brachii, when the arm is raised anteriorly to the horizontal.

- **Waist**: The circumference of the abdomen at its narrowest point between the lower costal (10th rib) border and the top of the iliac crest, perpendicular to the long axis of the trunk.

- **Gluteal (hip)**: The circumference of the buttocks at the level of their greatest posterior protuberance, perpendicular to the long axis of the trunk.

- **Mid-thigh**: The perimeter of the right thigh perpendicular to the long axis of the femur at the mid trochanterian-tibiale laterale level (the mid point between trochanterian and tibiale laterale landmarks).

- **Calf**: The circumference of the leg at the level of the Medial calf skinfold site®, perpendicular to its long axis.

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*The measurement of skinfolds, by an accredited specialist, provides insights into a player’s body composition that need to be interpreted alongside the results of other fitness tests as well as on-court performance*
2. court movement (speed, acceleration and agility)

20 m sprint test
The 20 m sprint is a standard fitness test used by many sports to assess a player’s near-maximal running speed. Concurrent evaluation of movement times at 5 m, 10 m and 15 m helps coaches to pinpoint any deficit in acceleration and/or speed.

Equipment
- Electronic timing gates set up at 0, 5, 10 and 20 m sprint lines.
- Tennis court or flat, non-slip surface to sprint 20 m (with ≥20 m run-off).
- Two cones are placed 3 m beyond the 20 m mark to ensure that the players do not decelerate approaching the 20 m mark.

Test procedure:
- Along a straight line, place marks at 0, 5, 10 and 20 m with masking tape. Align and synchronise the timing gates accordingly.
- Starting position is two-point, with the front foot up to the starting line (not 30 cm behind the line). Weight should be on front foot (so as to avert ‘swinging’).
- The player starts in their own time, sprinting without a racquet as fast as possible.
- Three trials are completed.
- The best time for each (5, 10 and 20 m) split is recorded, even if these times occur in different trials.
- Average velocities between the 5–10 m intervals can be calculated as appropriate.

505 agility test (right and left)
The 505 agility test is another fitness test common to sports that include frequent directional change. It helps coaches evaluate the qualities associated with a player’s ability to perform a single, rapid 180° change of direction over a short distance.

Players will be required to perform the test with both right and left foot pivots; approximating the mechanics that underpin movement to the extremes of the backhand and forehand side. Players will perform the traditional 505 that involves 10 m lead in or approach (i.e. “10-5-0-5”) before breaking the start beam as well as a modified 505 devoid of the initial 10 m approach. The protocol for the modified 505 is described below.

A ratio calculated between the best times recorded for the modified 505 and 10 m sprint will further aid assessment of the effectiveness with which individual players change direction.

Equipment
- Electronic timing gates.
- Up to 20 m of tennis court or another non-slip surface.
- Masking tape.
2. court movement (speed, acceleration and agility)

Modified 505 agility test (right and left)

Test procedure:
- The course and electronic timing gates (X) are set up as in the figure below.
- The player starts in a two-point stance with the front foot up to the start line with no part of the body crossing the line.
- The player can start when ready.
- The player will sprint from the start line, breaking the beam of the gates (set up at X), to the pivot line (5 m from the start line), where the player is to turn on either his/her right or left foot, ensuring part of the foot crosses the line, and then sprint back through the gates (X, 5 m from the pivot line).
- A minimum of two trials (interspersed with two minutes rest) need to be completed for both right and left foot pivots.
- The best 505 times (i.e. for the right and left foot pivots) should be recorded. These times will also be expressed relative to the player’s best 10 m sprint times ((505/best 10 m time) x 100)).

The ability to decelerate, change direction and then accelerate again is fundamental to tennis play and is assessed through the 505 agility test.
3. lower body power tests

**Counter movement jump (CMJ)**
This test provides an indirect measure of the mechanical power produced by the legs (i.e. predominantly the musculature responsible for hip, knee and ankle extension) when jumping vertically.

**Equipment**
- Yard-stick jumping device (such as Vertec).
- A flat, non-slip surface.

**Test procedure:**
- The player should stand side-on to the yard-stick jumping device and with heels remaining flat on the floor, reach upward as high as possible to displace the corresponding plastic vane.
- The player then jumps off both feet to achieve the maximum height possible. The player should be encouraged to execute a dip or counter movement immediately before upward propulsion.
- As the player jumps, arms are permitted to swing, displacing the vane at the maximum height of the jump. The take-off must be from two feet.
- Record the distance between the reach and the jump vanes to the nearest centimetre.
- The player should complete a minimum of three trials but may continue if still improving. Only the best trial is recorded.

**Single leg CMJ**
These tests are used in addition to the above test to assess discrepancies, if any, between right and left leg ‘vertical power’.

**Equipment**
- Yard-stick jumping device.
- A flat, non-slip surface.

**Test procedure:**
- The player should stand side-on to the yard-stick with heels remaining flat on the floor, reach upward as high as possible to displace the corresponding plastic vane.
- Players should then lift and flex their left leg so that they are standing on the right leg only.
- The left leg may swing back and forward to provide momentum to assist with coordination and height of jump.
- The player is then instructed to jump and reach upward as high as possible to displace the plastic vane at the maximum height of the jump.
- Record the distance between the reach and jump vanes to the nearest centimetre.
- The player should complete a minimum of three trials but may continue if still improving. Only the best trial is recorded.
- Repeat the above procedure with the player balancing on and jumping from the left leg.
4. strength tests

**Maximum push-ups**
The primary objective of this test will be to measure the local muscle endurance of players’ anterior (shoulder, chest and arm) musculature, and thus that which contributes to the repetitive velocity development of certain strokes. Initially, among some players, qualities more closely associated with maximum force production may be tested. As players will be required to maintain a neutral body alignment throughout, selected function of the musculature and structures charged with this responsibility will also be qualitatively assessable.

**Equipment**
- A flat, non-slip surface.
- Tennis ball.

**Test procedure:**
**To assume the start position:**
- Players lie in an extended prone (face down) position on the flat surface.
- Hands should be between shoulder width and no wider than two hand widths (outside the shoulders) apart. Palms should be in line with or just below the shoulder joint (i.e. head of the humerus). The players’ legs should be together and their feet tucked under so they are in contact with the floor.
- From this position, players either 1. fully extend their elbows, all the while maintaining a neutral body alignment. (A neutral body alignment should see the head, shoulders, trunk region, pelvis and legs all form a straight line. Virtually all dynamic movement should be performed about the elbow and shoulder joints.) or 2. maintain their hand alignment and move into a four point support (i.e. on knees) to assist their set up into the extended full body position.

**To complete a valid repetition:**
- In lowering their bodies to the flat surface, neutral body alignments need to be maintained and players will touch their chest to a tennis ball (positioned at the mid-chest or level or line with the xiphoid). In some circumstances, other points of controlled contact may be the pelvic region, nose and/or lower thighs. Players should not fall to nor support their bodyweight on the surface.
- To complete one repetition, players will then need to fully flex their elbows (touching the tennis ball) and successfully push-up and return to the start position.

- The movement should be continuous but performed at a controlled pace, with no more than a consecutive three second rest/stop at any point in the movement.
- Players should be encouraged to maintain an appropriate breathing rhythm (in: way down, out: way up).
- Players will receive one warning when they noticeably deviate from a neutral body alignment (i.e. hips sag or lift, head drops) or fail to keep to the tempo.
- Upon receipt of a second warning, players will cease the test, with their score amounting to their last successfully completed push-up.

**Recommended assessor position:**
- Side-on to the player and lowered (i.e. supported on bended knee).

**Maximum chin-ups**

**Equipment**
- Chin-up bar. The tallest player should not be able to touch the floor from the hanging (start) position.
- A mini-ladder or step.

**Test procedure:**
**To assume the start position:**
- Standing on a mini-ladder or step, players grasp the bar in a medium-width pronated (overhand) grip, with limits of shoulder-width and no wider than one hand width outside the shoulders. Players then hang in a fully extended elbow position.
- Athletes may choose the width of grip within limits but this must remain consistent over consecutive attempts and tests.

**To complete a valid repetition:**
- From the start position, players pull their bodies up in one smooth action so that the tops of their hands are level with the rear angle of the mandible (jaw). Players’ legs can be held semi-flexed or extended, however they must not move during the exercise. Players then hang in a fully extended elbow position.
- Players should be encouraged to maintain an appropriate breathing rhythm (in: way down, out: way up).
- Players will receive one warning when they breach correct technique as follows:
  - Not achieving correct height with head in neutral position;
4. strength tests

- Breaking of the hips and/or knees from start position during the lift;
- Body swing during the lift;
- Not going into full elbow extension between repetitions;
- Having >3 seconds rest between repetitions.

- A second warning or breach (of any nature) signals the end of the test. Scores will amount to the player’s last successfully completed chin-up.

**Recommended assessor position:**
- Side-on to the start position of the player.

**Other maximal strength assessments**
To be performed at the discretion of the Tennis Australia Physical Performance Coach with the necessary consideration given to the individual athlete’s musculoskeletal system and training age.

- Three repetition maximum bench press
- Three repetition maximum bench pull
- Three repetition maximum squat
- Three repetition maximum deadlift

These tests are administered in line with the National Protocols for the Assessment of Strength and Power endorsed by the Australian Sports Commission (2006).

*From this start position of the deadlift, the player will extend their ankles but most particularly their knees and hips to develop large amounts of force vertically – the likes of which often need to be generated and absorbed on the tennis court.*
This test is designed to not only evaluate maximum acceleration and speed of players, but more so their capacity to sustain these efforts repeatedly.

**Equipment**
- Electronic timing gates.
- Flat, non-slip surface to sprint 20 m (+ run off).

**Test procedure**
- Along a straight line, set up timing gates at 0 m and 20 m.
- Starting position is two-point, with the front foot up to the start line.
- The player sprints the 20 m course, with maximal effort, every 20 seconds for 10 consecutive times. Players will be given a countdown with 10s, 3s, 2s and 1s remaining, before leaving on “Go”.
- Players start each subsequent 20 m repetition where they finished the preceding repetition. If a player’s first sprint is not within 95 per cent of his/her previously recorded best 20 m sprint time, he/she is asked to rest for a minimum of 3 minutes before attempting the test again.
- All sprint times are recorded. Total time (for the 10 sprints) is calculated as well as the following percentage decrement:

\[
\text{Total time} - (\text{Best time} \times 10) \times 100
\]

\[
\text{Total time}
\]
6. Aerobic endurance test

*Multistage fitness test*

This test is largely considered an accurate and reliable measurement of aerobic power (Leger and Lambert, 1982; Leger et al., 1988). It is somewhat similar to tennis in that it requires players to repeatedly stop, start and change direction, and perhaps more significantly, can be easily administered with an entire squad or team simultaneously.

**Equipment**
- Multistage fitness test /20 m shuttle run test compact disc (CD).
- CD or mp3 player.
- Measured and marked 20 m flat, non-slip surface.
- Cones and/or masking tape.

**Test procedure:**
- Ensure that the players listen carefully to the instructions on the test.
- The test begins at level one following a brief explanation on the test.
- The test emits a single beep at regular intervals. A player must try to be at the opposite end of the 20 m track by the time the next beep sounds. After each minute, the time interval between beeps will decrease, so that the running speed will need to be increased. The first running speed is referred to as level one, the second speed as level two etc.
- Each level lasts approximately one minute and the test continues up to level 21. The end of each shuttle is denoted by a single beep; the end of each level is donated by a triple beep and by the commentator on the test.
- The player needs to place one foot on or behind the 20 m mark at the sound of each beep. Players who fail to reach the line at the sound of the beep will receive a warning that they will be eliminated if they are not at the opposite end of the 20 m track at the sound of the next beep.
- When near exhaustion, players falling short of the 20 m line twice in succession have their test terminated and their score recorded. Their score is their level and number of shuttles immediately previous to the beep on which they were eliminated.

**Note:** performing this test according to the specified protocol i.e. over 20 m, provides an estimate of aerobic capacity and therefore cardio-respiratory endurance, developed from evidence-based research. So, modifying the protocol to be conducted over 10 m may lead to errors in calculation of estimated maximal oxygen consumption. Additionally, performing the test over 10 m increases the number of changes in direction and may contribute to development of local muscular fatigue and thus offer a different insight into a player’s aerobic fitness.


PHYSICAL PERFORMANCE NATIONAL NORMS - MALE

<table>
<thead>
<tr>
<th>Age</th>
<th>n</th>
<th>Sprint (5m) (s)</th>
<th>Sprint (10m) (s)</th>
<th>Sprint (20m) (s)</th>
<th>Modified 505 Right (s)</th>
<th>Modified 505 Left (s)</th>
<th>Double Foot VJ (cm)</th>
<th>Push-ups</th>
<th>Chin-ups</th>
<th>Repeat Speed Ability (s)</th>
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PHYSICAL PERFORMANCE NATIONAL NORMS - FEMALE

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# Measures are reported relative to player bodyweight. Note: 505 Agility test norms in development.