



# MUSCULOSKELETAL ASSESSMENT FORM

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*Providing coaches, referees, players, and administrators with the knowledge, skills, and leadership abilities to ensure that safety and best practice principles are incorporated into all aspects of contact rugby.*

## **INTRODUCTION**

The purpose of musculoskeletal screening for athletes prior to participation in sport is an attempt to identify possible intrinsic risk factors for specific athletes, participating in specific sports, highlighting risk factors for specific injuries <sup>(1;25;31)</sup>. The ultimate aim of the risk identification is to include appropriate preventative strategies for individuals or sporting populations at risk for a specific injury in order to decrease the occurrence of injury <sup>(1;24)</sup>.

A number of problems exist when establishing a musculoskeletal screening. Firstly, many of the clinical tests described have not been validated and the reliability is unknown. Secondly, the tests need to be simple so that they can be easily administered in a variety of locations. Thirdly, the tests need to be inexpensive to administer, requiring as little equipment as possible. This increases the compliance of the professionals required to complete the tests. Furthermore it increases the number of subjects that can be tested which improves the relevance and meaning of risk factors identified within particular groups.

In an attempt to address a number of the problems highlighted above the following steps were taken. Firstly, wherever possible, tests were included which have been found to have good inter-tester and intra-tester reliability, unless otherwise indicated. Secondly, equipment needed for the protocol has been kept to a minimum. Thirdly, the number of tests have been reduced to improve compliance in completing the musculoskeletal screening.

The structure of the musculoskeletal has a large focus on the lower limb injury. The literature has shown that the lower limb is injured at a greater frequency (46-68% of total body injuries) <sup>(2;4;7;8)</sup>. Of the 10 most frequently described injuries sustained by England during the rugby World Cup (7) occurred in the lower limb <sup>(6)</sup>. As such these injuries receive more focus in the screening of the athlete.

The musculoskeletal form consists of two parts; the questionnaire and the musculoskeletal screening. The questionnaire is the most subjective area of the screening process but provides much information which is relevant to injury risk. When evaluating the risk of hamstring injury increasing age and a previous injury (within the last 12 months) were found to increase the risk of a hamstring injury <sup>(25;28)</sup>. A study to evaluate the validity of a 12 month injury recall found that football players were able to recall if they had experienced an injury – “Yes” or “No” within the last few months <sup>(27)</sup>. These players could recall very little of the diagnosis. Therefore, if the injury status is being related to a particular outcome measure they are likely to be accurate. If more detail than this is requested the validity of the questioning may be compromised. As such the following questionnaire is limited in the detail required. The information obtained in the questionnaire includes questions regarding training, injury, protective equipment, in accordance with recommendations in the current literature <sup>(25;28)</sup>.

The procedure for each test has been described in detail. As there are a number of different protocols used to describe a single test it is imperative that the procedure described in the manual be used to ensure the reliability of the test.

Where possible, normative data are provided; in some cases these data have not been obtained from rugby players. However, this problem will be addressed as the information on rugby players accumulates.

The following document has been compiled using similar protocols to those used in Australia and New Zealand. Researchers from these countries have been able to identify meaningful risk factors for a number of injuries as a result of the information collected from the questionnaires. This has enabled them to establish and implement rehabilitation or prehabilitation strategies to combat and reduce the risk of injury. The expected outcome of this document is similar, i.e.:

1. To provide South African medical professionals with a screening protocol which contains reliable, and where possible valid clinical tests.
2. To feedback risk factor findings with regards to specific injury profiles.

## **QUESTIONNAIRE**

The questionnaire was developed to retrieve the following information: the subject's age, playing history, level of experience and position played. Further information included training during the season, the preseason and the off season. The players warm up and cool down habits and the protective equipment used. Finally an injury recall was done. These items have been found to be reliable <sup>(28)</sup> and the injury recall over a 12 month period has been found to be valid <sup>(27)</sup>. The validity has been established for relating injury status to a particular outcome or risk factor. Details on diagnosis and particulars pertaining to the injury have limited accuracy, as described earlier.

The questionnaire is self explanatory requiring mostly YES/NO or numerical answers. However, due to the poor recall ability of players it is important that the injury recall component of the questionnaire be completed by the physiotherapist or medical professional with the player. This will increase the accuracy of the questionnaire.

## **POSTURAL ASSESSMENT**

### **Definitions**

Postural assessment is a very subjective component of the screening process. However, correlations do exist between injury and posture <sup>(12;32)</sup>.

### **Equipment required**

No specific equipment is required. However, if the subjects are able to stand against a grid placed on the wall it may increase the accuracy of the assessment.

### **Procedure**

The subject stands barefooted in a relaxed posture wearing shorts or swimming trunks. They need to stand a sufficient distance away to allow the person doing the rating to adequately view the posture. The different components of the postural assessment are viewed anteriorly, posteriorly and from the side (Figure 1, 2, 3). The following postural assessment was done:

- a) Shoulder symmetry: Are the shoulders level when viewed from the front or the back?
- b) Roundedness of shoulders: Observed from the front and side. Are the shoulders held in internal rotation with anterior translation of the humeral head?
- c) Thoracic spine alignment: This is observed from the side. Does the subject have an increased or decreased thoracic kyphosis?
- d) Spinal curvature: This is observed from behind. Does the subject have a spinal scoliosis?
- e) Lumbar lordosis. This is observed from the side. Does the subject have an increased lumbar lordosis or a flattened lumbar spine?
- f) Hip symmetry: Observed from the front or back. Are the hips level?
- g) Knee Hyperextension: This is observed from the side. Are the knees held in hyperextension?

**Rating:** Table 1 provides details on the rating system for the postural assessment

**Table 1. The rating scale for postural assessment as found in the musculoskeletal form**

Posture components	Rating scale		
	Normal	Mild asymmetry/ roundedness	Significant asymmetry/roundedness
Shoulder symmetry			
Shoulder roundedness			
Hip symmetry			
	Normal	Scoliosis convex left	Scoliosis convex right
Spinal curvature			
	Increased kyphosis/lordosis	Normal	Decreased kyphosis/lordosis
Thoracic kyphosis			
Lumbar lordosis			
	Normal		Knees hyperextended
Knee hyperextension			

**Reliability**

The reliability of a limited postural assessment was found to have acceptable Test-Retest reliability in a study which evaluated 10 components of posture <sup>(32)</sup>.



**Figure 1.** Posture viewed anteriorly



**Figure 2.** Posture viewed from the side



**Figure 3.** Posture viewed posteriorly

## **FLEXIBILITY TESTS**

### **ACTIVE KNEE EXTENSION TEST**

#### **Definition**

This test assesses the hamstring muscle length and the range of active knee extension in the position of hip flexion <sup>(18;19;26)</sup>

#### **Equipment requirements**

A support is required to maintain the position of 90° hip flexion. This support can be in the form of a wooden frame which is placed against the posterior thigh. A goniometer is required. A flexiometer can also be used to record the range.

#### **Procedure**

The subject lies supine with the leg to be tested in a flexed position. The therapist then places the support against the posterior thigh with the hip in a 90° of flexion. Alternatively an assistant can maintain the position of the thigh. The subject then actively extends the knee while keeping the foot relaxed. When final extension is reached the therapist supports the calf and measures the degree of knee extension relative to the vertical (Figure 2). If the therapist uses a goniometer the arms should be aligned as follows:

The fulcrum is placed of the lateral epicondyle of the femur.

The stationary arm of the goniometer is aligned with the lateral midline of the thigh with the greater trochanter as the reference point (This line should be perpendicular to the horizontal/plinth).

The moving arm is aligned with the lateral midline of the fibula, using the lateral malleolus as the reference point.

#### **Scoring**

The knee extension measurement is recorded in degrees (x), to the nearest degree. The final angle is calculated as 90° - x. If the subject is able to fully extend the knee, then the therapists flexes the hip 30° past the vertical. The hip extension angle obtained is then subtracted from 120° (120°-x).

#### **Reliability**

An intra class correlation coefficient (ICC) of  $r = 0.93$  (95% CI: 0.80-0.98) was obtained for inter-rater reliability. Intra-rater reliability was excellent with ICC figures of 0.96 and 0.94 <sup>(26)</sup>. The intra-rater reliability was confirmed by a further study <sup>(18;19)</sup>. The same study demonstrated a poorer inter-rater reliability. The reliability for this test was found to be 0.79 in a group of children age 10-13 and would therefore be a good test for this age group <sup>(50)</sup>.

### Normative data

Table 2. demonstrates the hamstring flexibility relative to risk of hamstring injury <sup>(28)</sup>. A hamstring flexibility recorded as an angle of less than 20°, although not significant, would appear to be most beneficial.

**Table 2: Active knee extension range (°) relative to hamstring injury.**

<b>Active knee extension</b>	<b>Number of subjects</b>	<b>% players who sustained hamstring injury</b>
<20°	81	9.9
21-30°	85	17.7
>30°	56	14.2



**Figure 4:** Position of measurement for the Active Knee Extension test

### PASSIVE STRAIGHT LEG RAISE

#### Definition

The straight leg raise test (SLR test) is used to measure the flexibility of the hamstrings <sup>(34;43;59)</sup>.

#### Equipment required

Plinth, pelvic belt and goniometer

#### Procedure

The subject is in a supine position on a plinth. The pelvis is placed in a posteriorly tilted position to allow the lumbar spine to come into contact with the plinth. This position can be maintained using a belt around the anterior superior iliac spines and the plinth but is not essential <sup>(29)</sup> (Figure 5).

EMG electrodes connected to a recorder can be placed on the hamstring muscle to measure electrical activity in the muscle as it is stretched. The electrodes should be placed in series with their centres 3 cm apart, between the center of the innervation zone of the biceps femoris and its distal tendon. All three electrodes should be placed on a line joining the origin and insertion of the muscle. The procedure of using electrodes does not have to be used.

The ankle joint is maintained in a neutral position. A flexible goniometer (South African Sport Science Institute of South Africa, Newlands, Cape Town, South Africa). A normal goniometer can be secured to the lateral side of the fibula to measure the angle of hip flexion. The subject's leg is lifted into hip flexion with maintenance of the knee extension. The degree of hip flexion is measured at either of these 4 end points: (i) as the tester feels the knee starting to flex; (ii) as the subject reports a feeling of marked discomfort, but no pain; (iii) when the tester determines the end feel of movement, and (iv) as a spike in the EMG activity from the electrodes is displayed on the monitor. The subject's leg is then returned to neutral.

### **Scoring**

The degree of hip flexion measured at either of the 4 points described in the procedure of the straight leg raise test is used as an outcome variable. A small degree of hip flexion would indicate less flexibility.

### **Reliability**

The mean correlation coefficient between tests conducted on day 1 and day 3 for the different variables of the straight leg raise test was 0.97, indicating excellent reliability <sup>(43)</sup>. A study that examined the influence of hip position on straight leg raise test found that hip position affected SLR relative to horizontal ( $p < 0.0001$ ) and pelvis relative to horizontal ( $p < 0.0001$ ) with an increase in measurement with the opposite hip flexed (11). A study compared 4 clinical tests designed to measure hamstring muscle length and found there was no significant difference between angles of passive SLR with pelvis strapped ( $61 \pm 6.7^\circ$ ) and SLR with low back flat ( $62 \pm 6.2^\circ$ ). The similar angles of SLR with pelvis strapped and with the low back flat and their significant relationship ( $r = 0.70$ ,  $p < 0.001$ ) indicated the different test procedures had minimal influence on the test results <sup>(29)</sup>.

### **Normative Data (adapted from<sup>(36;59)</sup>).**

These studies indicated that less than  $90^\circ$  on a straight leg raise test was considered a risk factor for primary or first time hamstring strains.

	<i>Witvrouw 2003</i> <sup>(59)</sup> (n=146)	<i>Jonhagen 1994</i> <sup>(36)</sup> (n=11)
<b>Hamstring Range</b>	90°	90°
<b>Study Design</b>	Prospective.	Retrospective.
<b>Sex</b>	Male	Male
<b>Age (years)</b>	Unknown	22.0 years
<b>Population</b>	Professional soccer players	Sprinters
<b>Measurement</b>	Goniometric measure. of hamstring, quadriceps, adductors Calf	SLR
<b>Injury definition</b>	Clinical diagnosis	Clinical diagnosis
<b>No. of ham. Injuries</b>	31	11



Figure 5. Position of measurement for the Passive Straight Leg raise.

## **MODIFIED THOMAS TEST**

### **Definition**

The Modified Thomas test is used to assess the flexibility of the hip flexors (iliopsoas) and the knee extensors (quadriceps). In addition the test provides a measure of hip abduction <sup>(18;19;26;31)</sup>.

### **Equipment required**

A plinth and goniometer are required for this test.

### **Procedure**

The procedure has been described in a number of texts <sup>(18;19;26;31)</sup>. The subject sits on the edge of the end of the plinth. The subject then rolls back on the plinth and pulls up both knees to the chest. This ensures that a flattened lumbar spine is achieved with a posteriorly rotated pelvis. The subject holds the

contralateral leg in flexion against the chest while lowering the test leg towards the floor. The lower leg is allowed to hang freely so that the end position is obtained with gravity alone.

**Measurement of the iliopsoas:** The angle of hip flexion is used to determine the iliopsoas length (Figure 6). The goniometer is positioned as follows:

- a) The axis of the goniometer is aligned with the greater trochanter.
- b) The stationary arm is aligned with the lateral midline of the pelvis (the horizontal).
- c) The moving arm is aligned with the midline of the femur using the lateral epicondyle as a reference point.

**Measurement of the quadriceps:** The angle of knee flexion is used to determine the length of the quadriceps (Figure 7). The goniometer is positioned as follows.

- d) The axis of the goniometer is placed over the lateral epicondyle of the femur.
- e) The stationary arm is aligned with the lateral midline of the thigh (line of the femur).
- f) The movable arm is aligned with the fibula using the lateral malleolus as a reference point.

**Scoring**

Both measurements are taken to the closest degree (°).

**Reliability**

The ICC's for this flexibility test were between 0.91-0.94 <sup>(31)</sup>.

**Normative data**

The mean flexibility for the iliopsoas and quadriceps is presented in table 3.

Table 3. The mean flexibility for the iliopsoas and quadriceps. The standard deviations are shown in brackets (adapted from <sup>(31)</sup>)

	<b>Joint angles (°)</b>	
<b>Sport</b>	<b>Iliopsoas</b>	<b>Quadriceps</b>
Rowing	-10.7 (6.0)	56.0 (8.4)
Basketball	-11.8 (4.9)	53.5 (6.6)
Running	-14.2 (4.7)	50.6 (7.9)
Tennis	-10.9 (6.0)	49.9 (5.6)
Average	-11.9 (5.6)	52.5 (7.6)



Figure 6. Position of measurement for the Modified Thomas test (hip flexors)



Figure 7. Position of measurement for the Modified Thomas test (knee extensors)

## **ACTIVE HIP INTERNAL AND EXTERNAL RANGE OF MOVEMENT**

### **Definition**

This test assesses the active range of hip rotation in a neutral position <sup>(18;19)</sup>. It is proposed that increased hip internal rotation is an indicator of inadequate gluteus medius control <sup>(46)</sup>.

### **Equipment requirements**

A plinth and a goniometer are required for this test.

### **Procedure**

This test is described with a player both in a supine position and prone with the hip in neutral. The intra-rater reliability of hip rotation assessed in either position is very good, but the inter-rater reliability was better measuring hip range of movement in supine <sup>(18;19;26)</sup>. For this reason the test will be described in supine.

The subject lies supine on a plinth with the hip in neutral and the lower leg hanging freely over the edge of the plinth. The opposite leg is flexed at the hip and knee with the foot on the plinth. The subject is asked to internally rotate the hip to maximum without movement at the pelvis (Figure 8). The goniometer is positioned as follows:

- a) The axis of the goniometer is placed over the mid-point of the patella.
- b) The fixed arm is held vertically.
- c) The movable arm is placed along the length of the patella

This is repeated for hip external rotation (Figure 9).

### **Scoring**

The measurement is recorded to the nearest degree (°).

### **Reliability**

The inter-rater reliability for the assessment of hip rotation range in supine is 0.94 (Internal rotation) and 0.88 (External rotation) <sup>(26)</sup>. The intra-tester reliability was also excellent with an ICC between 0.83 - 0.92 for internal rotation and 0.83 – 0.90 for external rotation. These findings were further supported by Pua et al. <sup>(48)</sup>. The inter-observer reliability of this measurement in the prone position was poor and is therefore discouraged <sup>(18;19)</sup>

### **Normative data**

Normative data for hip internal rotation and external rotation is presented for Tennis players and baseball pitchers (Table 4) <sup>(21;35)</sup>. In a group of soccer players, the injured players (adductor strain) had a decrease in the cumulative hip rotation range of movement (45°) versus the uninjured players (54°) <sup>(35)</sup>. In a group of cricketers it was found that bowlers with a hip internal range of motion less than 30° had a decreased risk of injury <sup>(18;19)</sup>. The relationship between injury and range in rugby players needs further investigation.

Table 4: Normative hip internal and external rotation range of movement. (Values are expressed as mean ± standard deviation).

<b>Parameter and group</b>	<b>Dominant hip</b>	<b>Non Dominant hip</b>
Tennis players		
Hip internal rotation	27 ± 10	26 ± 8
Hip external rotation	37 ± 9	36 ± 9
Baseball pitchers		
Hip internal rotation	37 ± 10	35 ± 11
Hip external rotation	36 ± 9	35 ± 9



**Figure 8:** Position of measurement for active hip internal rotation range of movement.



**Figure 9:** Position of measurement for active hip external rotation range of movement

### ***ANKLE DORSIFLEXION LUNGE***

#### ***Definition***

This test is used to assess the dorsiflexion range of movement at the ankle joint <sup>(3;18;19;25)</sup>

#### ***Equipment required***

This procedure needs to be done against a wall. A standard tape measure (cm) is needed.

#### ***Procedure***

Subjects are required to position their foot so that a line drawn through the heel and the big toe are aligned on a tape measure on the floor. A vertical line is drawn on the wall in line with the tape measure.

The subject is instructed to lunge forward so that their knee touches this vertical line. The leg not being tested can rest on the floor. Subjects are able to hold onto the wall for support. The heel is required to remain in contact with the floor at all times (Figure 10). Three attempts are allowed. The maximum distance from the wall to the tip of the big toe is recorded.

The therapist conducting the test may hold the subject's heel to ensure contact is maintained with the floor. Pronation and supination of the front foot was not limited.

### **Score**

The distance is measured in centimeters (cm) to the closest 0.1 cm.

### **Reliability**

The inter-rater reliability for the distance measured for the ankle dorsiflexion lunge was  $R = 0.99$  (95% CL: 0.97-0.99) <sup>(3)</sup>. The intra-rater reliability of the measurement was excellent (ICC between 0.98-0.99). These findings were further supported by a further reliability study <sup>(18;19)</sup>.

### **Normative data**

The mean range of ankle dorsiflexion in the reliability study was  $13.9 \pm 3.8$  cm <sup>(3)</sup>. Studies evaluating the risk of injury using the ankle dorsiflexion lunge suggested that a measure less than 10 cm increased the player's risk of sustaining a hamstring injury <sup>(25)</sup>. This however, needs to be verified in further studies. Other studies showed that cricket fast bowlers had a significantly decreased risk of injury if the range was greater than 14 cm <sup>(18;19)</sup>



**Figure 10.** Position of measurement of the ankle dorsiflexion lunge

## **SIT AND REACH TEST**

### **Definition**

The sit and reach test is commonly used to measure combined spinal and hamstring muscle flexibility.

### **Equipment requirements**

A sit and reach box is required. This is a box which has a perpendicular surface against which the feet can be placed. The top of the box has an overhanging piece which extends over the subject's toes towards the subject. A ruler is fixed on top of the sit-reach box, such that the zero line of the ruler coincided with the vertical line of the feet <sup>(25;26)</sup>. Older studies have positioned the ruler at 23 or 26 cm. Therefore, it is important to consider this when normative data from studies using this type of box are used. If an old sit and reach box is used simply subtract 23 or 26 cm to obtain the final score.

### **Procedure**

The subject sits with the soles of his feet against a sit-reach box with knees fully extended. The subject is instructed to flex maximally at both hips and lower back. One hand should be held directly on the top of the other - this position is held for 1 second (Figure 11).

### **Scoring**

The furthestmost point reached by the subject's middle finger is measured off the ruler to the nearest 0.5 cm.

### **Reliability**

Johnson and Nelson (1979) have documented the reliability of the test. However, a subsequent study supported the validity of the sit and reach test as a measure of hamstring flexibility, but not lower back flexion range of motion <sup>(41)</sup>. The intra-rater reliability is  $r = 0.99$  (95% ICC: 0.98-1.00) and  $0.98$  (95% ICC: 0.94-0.99)<sup>(26)</sup>. The inter-rater reliability for sit and reach is  $0.97$  (95% CI ICC: 0.91-0.99) and  $0.98$  (95% CI: 0.97, 0.99)<sup>(26;51)</sup>.



**Figure 11.** Position of measurement for the sit and reach test

**Normative data**

In a study investigating the risk factors of hamstring injuries in elite Australian football, an increased sit and reach score was associated with a slighter higher relative risk of injury than a reduced sit and reach <sup>(25)</sup> (Table 5). Although this was not significant it does indicate that the previous sit and reach scores which implied the greater the sit and reach score the less likely the player is to be injured, needs to be re-evaluated.

Table 5. The sit and reach scores and relative hamstring injury risk (adapted Gabbe et al <sup>(25)</sup>)

<b>Sit and reach</b>	<b>Number of subjects</b>	<b>Relative risk of hamstring injury</b>
>10cm	62	12.90
1-10cm	95	14.74
< 0cm	64	12.50

**LUMBAR SPINE EXTENSION RANGE OF MOVEMENT****Definition**

This test is used to assess the range of movement of the lumbar spine extension <sup>(26)</sup>.

**Equipment required**

A tape measure.

**Procedure**

The subject stands with feet shoulder width apart. The subject is instructed to fully extend his spine keeping his knees straight at all times. At the same time the subject is required to reach as far down the back of the leg as possible. The distance from the tip of the left middle finger to the middle of the popliteal crease is measured using a tape measure (Figure 12). If there is pain at any point during the test this must be recorded.

**Score**

The measurement is recorded to the closest 0.1 cm. If the subject's finger reaches above the popliteal crease the measurement is recorded as a positive (+), and if the finger reaches below the popliteal crease it is denoted with a negative sign (-).

**Reliability**

The inter-rater reliability was  $R = 0.95$  (95% CI ICC: 0.85-0.99). The intra-rater reliability was 0.86 and 0.89 respectively <sup>(26)</sup>

### **Normative data**

This method of evaluating lumbar extension has not been reported extensively. Normative data needs to be collated for rugby union players. The mean range for this test obtained in the reliability study was  $9.7 \pm 4.5$  cm.



Figure 12. The position of measurement for lumbar spine extension range of movement

### **FORWARD FLEXION OF THE LUMBAR SPINE**

#### **Definition**

This test is undertaken to assess the forward flexion range of the lumbar spine. This test is described as a routine test when evaluating the lumbar spine of athletes <sup>(10)</sup>. In addition, this tests aims to identify areas of the thoracic and lumbar spine which do not follow the natural curve of the back and represent areas of stiffness. These represent areas where there is limited segmental stability. As such this test assists in identifying areas with a dysfunction of the deep trunk stabilizers.

#### **Equipment required**

Tape measure is required.

#### **Procedure**

The subject is asked to stand with his legs shoulder width apart. He is then instructed to flex his lumbar spine forward getting the upper body relaxed with arms outstretched towards the floor (Figure 13). The subject's knees must remain extended at all times. The distance from the floor to the tip of the middle finger is measured. If a subject is able to touch the floor with any part of the hand the subject is given a

score of 0. The tester then views the curvature of the thoracolumbar spine to identify areas of stiffness (Figure 14).

**Scoring**

The amount of forward flexion is recorded to the closest 0.1 cm. The tester must mark “*is there stiffness: Yes/No*” and then identify the vertebral levels which are stiff by ticking the relevant blocks provided on the screening form (Table 6).

Table 6. Table for Forward flexion in the musculoskeletal screening form.

	<i>Yes</i>	<i>No</i>
<b>Level of segmental stiffness</b>		
Lumbar stiffness (L1-5)		
Lower thoracic stiffness (T7- T12)		

**Reliability**

The authors have not been able to find any studies which have validated this test. However, the clinical relevance of this test in assessing the segmental control of the thoracolumbar spine is deemed significant. It is acknowledged that this test may be compromised by the lack of clinical experience of the physiotherapist.

**Normative data**

No normative data exists for a test of this nature. The clinical relevance of the stiff segments is of importance. Scores of “normal” or “ideal” would represent a spine which has a constant curve free of any stiff segments.



Figure 13. The position of measurement for forward lumbar flexion



Figure 14: Identifying areas of stiffness in the lumbar spine during forward flexion (L2-4)

### **COMBINED ELEVATION TEST**

#### **Definition**

The combined elevation test assesses combined thoracic extension (strength and range of motion), shoulder girdle flexion and scapula retraction <sup>(18;19)</sup>.

#### **Equipment required**

A tape measure.

#### **Procedure**

The subject lies prone on the floor with both arms outstretched above his head. The elbows are extended, thumbs locked and palms facing the floor. The subject is instructed to keep his feet, chin, chest and hips on the ground at all times. The subject is instructed to breath in, hold his breath and then raise both arms off the floor as high as possible maintaining extension of the elbow. The measurement is taken from the base of the metacarpal of the thumb to the floor in a perpendicular line (Figure 15).

#### **Score**

The measurement is taken to the closest 0.1 cm.

#### **Reliability**

The inter-rater reliability was good with an ICC of  $R = 0.87$  (95% CI: 0.63-0.97). The intra-rater reliability is 0.97 (95% CI: 0.88-0.99) <sup>(18;19)</sup>.

#### **Normative data**

No normative data exist for rugby players for this test.



Figure 15. The position of measurement for the combined elevation test

## **SHOULDER EXTERNAL/INTERNAL ROTATION**

### **Definition**

Shoulder internal rotation and external rotation measurements are representative of posterior and anterior capsular tightness respectively <sup>(42;45;56)</sup>. Athletes trained for sports which involve activities and movements above their heads demonstrate an adaptive increase in shoulder external range of motion with a concurrent decrease in internal range of motion <sup>(5;9;17)</sup>. As a result of these findings a combined range of motion is assessed to determine the relevance of capsular tightness in the shoulder.

### **Equipment required**

A plinth and goniometer is required. An assistant increases the accuracy of the measurement.

### **Procedure**

The subject lies supine on a plinth and the tester moves the humerus to 90° abduction in the coronal plane <sup>(42)</sup>. The scapula is stabilized by the tester's hand while the shoulder is moved into internal rotation (Figure 16). The goniometer is positioned as follows:

- a) Axis of the goniometer is placed over the area of the joint centre of the elbow.
- b) The stationary arm is maintained in a vertical plane, perpendicular to the plinth.
- c) The moving arm lies in the line of the ulna with the centre of the wrist as the point of reference.

This procedure is repeated with the shoulder in external rotation (Figure 17).

**Scoring**

These angles are measured to the nearest degree (°).

**Reliability**

The reliability of testing internal and external rotation with a goniometer has been established <sup>(22)</sup>.

**Normative data**

There are no normative data for rugby players. However, the following normative data are available for a range of athletes (overhead and non-overhead) (Table 7).

Table 7: Normative values for the internal and external rotation of the shoulder. Data are expressed as the mean ± standard deviation.

		<b>Baseball pitchers</b>	<b>Tennis players</b>	<b>Non-overhead athletes</b>
Internal rotation	Dominant shoulder	41.7 ± 5.9 °	34.7 ± 7.5°	46.3 ± 13.1°
	Non-dominant shoulder	54.3 ± 8.3 °	45.7 ± 7.5°	47.5 ± 13.0°
External rotation	Dominant shoulder	132.0 ± 10.4 °	129.6 ± 12.4°	120.3 ± 7.0°
	Non-dominant shoulder	119.7 ± 6.5 °	120.7 ± 12.7°	114.0 ± 6.1°

(Adapted from <sup>(45)</sup>)



Figure 16. The position for measurement of shoulder internal rotation



Figure 17: The position for measurement of shoulder external rotation

### ***SUPINE POSTERIOR SHOULDER TIGHTNESS ASSESSMENT***

#### ***Definition***

This test is used to assess the range of horizontal adduction of the shoulder. As this range of movement is limited by the posterior capsule this test is used to assess for posterior capsule tightness <sup>(45)</sup>.

#### ***Equipment required***

A plinth and a goniometer are required. An assistant is necessary to stabilize the scapula while the tester measures the range of movement.

#### ***Procedure***

The subject lies supine on the plinth. The subject is instructed to maximally retract the scapula. The tester then stabilizes the lateral border of the scapula. The tester then passively moves the subject's arm into horizontal adduction with neutral humeral rotation (Figure 18). The measurement is recorded with a goniometer as follows:

- a) The axis of the goniometer is placed over an estimated glenohumeral joint centre.
- b) The stationary arm of the goniometer is held maintained in a horizontal position, parallel to the plinth.
- c) The moving arm of the goniometer was aligned with the humerus.

#### ***Scoring***

This angle is recorded to the nearest degree (°).

**Reliability**

The inter-tester, intra-session, and intersession reliability for this test were ICC = 0.94, 0.91 and 0.75, respectively, indicating generally good reliability for this test. Further, this test was found to have good validity as it was able to identify differences between non-overhead and overhead athletes <sup>(45)</sup>.

**Normative data**

Normative data for this test is presented in Table 8.

Table 8: Normative values for the posterior shoulder tightness test. Data are expressed as the mean ± standard deviation.

	<i>Baseball pitchers</i>	<i>Tennis players</i>	<i>Non-overhead athletes</i>
Dominant shoulder	105.9 ± 5.9 °	103.9 ± 7.6 °	107.0 ± 6.8 °
Non-dominant shoulder	114.1 ± 9.2 °	111.9 ± 6.5 °	107.9 ± 10.3 °

(Adapted from Myers et al<sup>(45)</sup>)



**Figure 18.** The position for measurement of posterior shoulder tightness.

## **NEURAL MOBILITY TESTS**

### **ACTIVE SLUMP TEST**

#### **Definition**

The slump test is used to assess the mobility and sensitivity of neuromeningeal structures <sup>(55)</sup>.

#### **Equipment required**

A goniometer or inclinometre and a plinth are required.

#### **Procedure**

The subject sits with his lower legs hanging over the edge of the plinth. The subject is instructed to place his hands behind his back and flex the cervical spine, followed by the thoracic and lumbar spine. This is followed by full dorsiflexion. Finally knee extension is performed until the subject feels either discomfort or stretch (Figure 19). The degree of knee extension is measured with a goniometer as follows:

- a) The fulcrum is placed on the lateral epicondyle of the femur.
- b) The stationary arm of the goniometer is aligned with the lateral midline of the thigh with the greater trochanter as the reference point (This line should be parallel to the horizontal/plinth).
- c) The moving arm of the goniometer is aligned with the lateral midline of the fibula, using the lateral malleolus as the reference point.

#### **Scoring**

The knee flexion angle is measured in degrees.

#### **Reliability**

The inter-rater reliability for this test was ICC = 0.92 (95% CI: 0.77-0.97) and an intra-rater reliability of ICC = 0.95 and 0.80 <sup>(26)</sup>.

#### **Normative data**

A study of Australian football players showed that there is a greater risk of injury if knee flexion during the active slump test is greater than 15° (Relative Risk (95%CI): 0.6 (0.2-1.9) (28). However, another study of Australian footballers did not find a relationship between active slump test results and hamstring injury <sup>(25)</sup>.



Figure 19. Position of measurement of the active slump test

### **UPPER LIMB TENSION TEST (ULTT1) (MEDIAN NERVE BIAS)**

#### **Definition**

The upper limb tension (brachial plexus) test (ULTT1) is used to examine the mobility of the brachial plexus and has a bias to the median nerve <sup>(52)</sup>. The indirect confirmation of the specificity of the ULTT1 to a median nerve bias has been demonstrated <sup>(14)</sup>.

#### **Equipment required**

Plinth and goniometer

#### **Procedure**

For the ULTT1 the following sequence of movements is suggested:

1. The subject lies supine on the plinth in a neutral body position.
3. The cervical spine is placed in contralateral lateral flexion.
4. The therapist depresses the ipsilateral shoulder girdle.
5. The shoulder is then placed in abduction.
6. This is followed by wrist and finger extension.
7. Forearm supination
8. Lateral rotation of the shoulder
9. Elbow extension
10. Ipsilateral lateral flexion of the cervical spine

One angle can be measured with a goniometer:

The degree of mobility in the median nerve is determined by measuring the angle of elbow extension in the following manner:

- a) The stationary arm of the goniometer is aligned with the humerus of the upper limb.
- b) The moving arm of the goniometer is aligned with the ulnar of the forearm using the medial epicondyle as a reference point.

### **Scoring**

To the nearest degree

### **Reliability**

The intra-rater reliability has been examined, and the parameters of a positive test have been defined but there is lack of randomized controlled trials <sup>(58)</sup>. The intra- and inter-tester reliability within the same session was excellent ( ICC = 0.95; standard error of measurement (SEM) = 4.9°). Reliability after a 48-hour interval was moderate (ICC = 0.69; SEM = 9.9 °). The reliability coefficients for the symptomatic group within the same session were comparable with the excellent results of the asymptomatic group, for both the laboratory (ICC = 0.98; SEM = 2.8 °) and clinical settings (ICC = 0.98; SEM = 3.4 °) <sup>(13)</sup>.

### **Normative Data**

Normal responses to the ULTT1 have been documented as a deep ache or stretch in the cubital fossa extending to the anterior and radial aspects of the forearm and hand, tingling in the thumb and first three fingers, a stretch feeling over the anterior aspect of the shoulder. Contralateral cervical lateral flexion increased symptoms while ipsilateral cervical lateral flexion reduced the symptoms.

**A significant increase in muscle activity was found between 90° elbow flexion and onset of pain; end of range of elbow extension and end hold of the ULTT <sup>(54)</sup>.**



**Figure 20.** Position for the ULTT1

## **STABILITY AND STRENGTH**

### **PRONE 4 POINT HOLD (PLANK)**

#### **Definition**

The plank test is used to determine the relative strength of the global stabilizers of the body namely the transversus abdominus, internal and external obliques, and scapula stabilizers <sup>(18;19)</sup>.

#### **Equipment required**

Timer

#### **Procedure**

The subject is requested to bridge for as long as he can and is timed while maintaining the position (Figure 21). He is marked as “satisfactory”, “unsatisfactory” or “good”. The tester notes the following points: The player is requested to stop the test if he demonstrates:

- a) Increased dipping of lumbar back
- b) Shaking or any signs of fatigue
- c) Shoulder dipping

In the absence of any of the above signs, the test is terminated by the player when they are unable to maintain the testing position any longer.

#### **Scoring**

The measurement is recorded to the nearest second.

#### **Reliability**

The inter-observer reliability and intra-observer reliability has been documented as  $R = 0.89$  (95% CI: 0.79-0.97) and  $0.89$  (95% CI: 0.62-0.97) respectively <sup>(18;19)</sup>.

#### **Normative data**

- Unsatisfactory: his time is less than 3 minutes and exhibits signs of fatigue as described above
- Satisfactory: his time is 3 minutes and does not show any signs of fatigue.
- Good: his time is greater than 3 minutes and does not show any signs of fatigue.

Time position sustained	
Lumbar dipping	
Shoulder dipping	
Shaking	
Result:	

There are no published normative data on this technique.



Figure 21: The position for measurement of the prone 4 point hold test

## **BRIDGING HOLD**

### **Definition**

This test is used to assess core strength. In particular this is used to assess gluteal musculature strength and endurance <sup>(18;19)</sup>

### **Equipment required**

A stop watch is required.

### **Procedure**

The subject lies supine on the floor with both knees bent at 90°. The subject is then instructed to lift his hips and pelvis off the floor to achieve a straight line between the shoulder, pelvis and knee. The subject then extends his contralateral knee and uses the gluteal muscles to maintain the line through the shoulder, hip and knee (Figure 22). The left and right anterior superior iliac spine (ASIS) must remain level and there must be no arching in the lower back. The stop watch is started as soon as the knee is extended. The subject holds this position for as long as they can, until they can no longer hold the position, the tester determines they cannot hold the position or the subject experiences pain in the lower

back or hamstring. The tester can disqualify the subject if the alignments described above are not maintained. A single warning may be given, thereafter the subject is disqualified. The timing is stopped at this stage. The reason for termination of the test must be recorded on the table given in the musculoskeletal form (Table 9).

**Scoring**

The duration of the hold is recorded to the nearest second.

**Reliability**

The intra-tester and inter-tester reliability for this test were  $R = 0.56$  (95% CI: 0.00, 0.83) and  $0.56$  (95% CI: 0.42-0.88) respectively <sup>(18;19)</sup>. This reliability is poor. However, the test is still considered to be relevant as a clinical evaluation. Therefore the criteria for termination have been given in more detail and a reason for termination table (Table 9) provided. However, future studies will be required to further evaluate this.

Table 9: Reasons for termination of the Bridging Hold test

<i>Reason for termination of the test</i>	<i>Mark with yes (more than 1 reason may be given)</i>
Pain in the lower back	
Pain or cramping in the hamstrings	
Unable to maintain the alignment of the shoulder, hip and knee	
Unable to maintain the alignment of the ASIS	
General fatigue	
Other	

**Normative data**

There are no published normative data for this test.



Figure 22. The position for measurement of the Bridging Hold test

## **CALF HEEL RAISES**

### **Definition**

This test assesses the muscle endurance of the ankle plantarflexors <sup>(18;19)</sup>.

### **Equipment needed**

A step

### **Procedure**

The subject stands barefoot with the ball of his foot on the step. One foot is tested at a time with a 5 minute interval between the two testing sessions. The subject is instructed to rise onto the ball of the foot as high as possible and then lower his heel. The knee should remain extended at all times (Figure 23). The heel raises need to be performed at one cycle per second. The subject is instructed to continue until he is unable to complete a full plantarflexion/dorsiflexion range of movement, or voluntarily stops due to fatigue.

### **Scoring**

This is the number of heel raise/lower cycles completed by the subject.

### **Reliability**

The inter-tester and intra-tester reliability for this test was excellent with ICC of 0.99 (95% CI: 0.98, 1.00) and 0.99 (95% CI: 0.97, 1.00) respectively <sup>(18;19)</sup>.

### **Normative data**

The reliability of this test has only recently been established. In a paper using this test it was found that 43% of the cricket fast bowlers tested were able to perform between 16-25 repetitions. A further 23% of these bowlers performed less than 15 repetitions, while the remaining 35% could perform greater than 25 repetitions <sup>(19)</sup>.



Figure 23: Position for Calf Raises test

### ***THE CRANIO-CERVICAL FLEXION (C-CF) OR NECK FLEXOR MUSCLE ENDURANCE TEST***

#### ***Definition***

The cranio-cervical flexion test of the neck is used to determine the relative strength of the global stabilizers of the neck namely the sternocleidomastoid and the deep neck flexors i.e. deep longus capitis and colli muscles <sup>(37;38;40)</sup>. This test was first described using pressure biofeedback. However, further studies have indicated that more accurate measurements can be obtained using a cranio-cervical dynamometer (ICC 0.70 - 0.92) <sup>(47)</sup>. The following description of the neck flexor endurance test does not require sophisticated equipment. The test has good reliability <sup>(30)</sup>.

#### ***Equipment required***

Plinth, skin marker and stopwatch

#### ***Procedure***

The neck flexor muscle endurance test is performed in a supine, crook-lying position and can be defined as follows: with the chin maximally retracted and maintained isometrically, the subject lifts the head and neck until the head is approximately 2.5 cm above the plinth while keeping the chin retracted to the chest (Figure 24). Once in position, a line is drawn across 2 approximated skin folds along the subject's neck, and the therapist places his or her left hand on the table just below the occipital bone of the subject's head. Verbal commands (i.e. "Tuck your chin" or "Hold your head up") are given when either the line edges begin to separate or the subject's head touches the therapist's left hand. The test is terminated if the edges of the lines no longer approximate each other due to loss of chin tuck or the subject's head touches the therapist's hand for more than 1 second <sup>(30)</sup>.

### **Scoring**

The time (to the nearest second) that the subject could hold the test position is measured.

### **Reliability**

Intraclass correlation coefficients (ICC for inter-tester and intra-tester reliability of the neck flexor muscle endurance test measurements were calculated for subjects with and without neck pain <sup>(30)</sup>. Intra-tester reliability ranged from good to excellent (ICC R = 0.82 – 0.91) for subjects without neck pain. Inter-tester reliability was moderate to good (ICC R = 0.67–0.78) for subjects without neck pain and was moderate (R = 0.67) for subjects with neck pain. Neck flexor endurance time was significantly greater in the group without neck pain ( $38.95 \pm 26.4$  s) compared to the group with neck pain ( $24.1 \pm 12.8$  s) <sup>(30)</sup>.

### **Normative Data**

There are no published normative data for the neck flexor endurance test. However, the ability to maintain the nodding position for 30 seconds is considered normal muscle control and endurance of the global neck stabilizers. This has however not been tested. Jull <sup>(38)</sup> reported that normal function of deep neck flexors is the ability to hold this contraction 10 times.



**Figure 24.** The position for testing the deep neck flexor strength.

## **PROPRIOCEPTION**

### **MULTIPLE HOP TEST (PROPRIOCEPTION)**

#### **Definition**

The Multiple hop test was used to evaluate dynamic postural control <sup>(49)</sup>. However, this test has been used to differentiate between subjects with and without chronic ankle instability and has been validated for this purpose <sup>(20)</sup>.

#### **Equipment needed**

A stop watch and white adhesive markers are needed (2 cm X 2 cm).

#### **Procedure**

The set up before testing may require some time and therefore wherever possible the testing should be done for groups rather than individuals. The adhesive markers are laid out as outlined in figure 25 prior to testing the left and right leg. The distance between markers is determined by the subject's height (Table 10). It is therefore recommended that a number of these circuits are set out prior to testing, particularly if a group is being tested.

Table 10: The inter-tape distances for the Multiple hop Test <sup>(20;49)</sup>

<b>Height (cm)</b>	<b>Diagonal distance (cm)</b>	<b>Adjacent distance (cm)</b>
150.0 - 159.9	70	49
160.0 - 169.9	74	53
170.0 - 179.9	79	56
180.0 - 189.9	83	59
190.0 - 199.9	88	62
200.0 - 209.9	92	66

The subjects are given instruction for the test prior to testing. The subjects are able to complete one practice trial prior to testing. The subjects start on the start mark with hands on hips and supporting leg extended. The stop watch is started coinciding with the "go" signal. Alternatively, this test can be videotaped and assessed at a later stage. The subject has to hop on the same leg in numerical order, landing on the adhesive marker - a deviation of one foot width is allowed. The subjects have to maintain balance and avoid making any postural corrections during hopping or landing. These include;

- falling,
- displacing the supporting foot,

- touching the ground with the non-supporting foot,
- losing hands from the hips,
- moving the trunk medially or laterally,
- flexing the trunk forward, and
- swinging the non-supportive leg  $>30^\circ$  laterally into the frontal plane.

The subject is only allowed to continue hopping when he is stationary and is once again in the starting body position. In the event of falling over the subject has to quickly restart on the block prior to falling. The timing is stopped when the subject is in a controlled position on the last marker.

Trials are restarted when the following conditions occur:

- a) The subject's supporting leg is not fully extended prior to jumping to the next square on 3 or more occasions.
- b) The subjects lands outside of the predefined area on 3 or more occasions
- c) When the subject looks at the marker he is jumping to 3 or more times while jumping or landing
- d) When on 3 or more occasions subjects do not stand in a controlled manner prior to jumping to the next square.

### **Reliability**

The test-retest reliability of this test was good to excellent. The ICC's of the unstable ankles was  $R = 0.91$  (left ankle; CI: 0.80-0.95) and  $R = 0.97$  (right ankle; CI: 0.94-0.98). The ICC for the right and left ankle of the healthy subjects was  $R = 0.87$  (left ankle; CI: 0.71-0.94; right ankle; CI: 0.65-0.94) <sup>(20)</sup>. The test was able to discriminate between subjects with unstable ankles and healthy ankles. Subjects with unstable ankles took significantly longer to complete the test <sup>(20)</sup>.

### **Normative data**

There are limited data available for this test as it is newly validated. The data presented in table 11 below represents healthy subjects participating in recreational sport.

**Table 11:** Time taken to complete the Multiple hop test. Data are expressed as the mean  $\pm$  standard deviations

	<i>Left ankle</i>	<i>Right ankle</i>
Unstable ankles (seconds)	38.6 $\pm$ 7.6	40.5 $\pm$ 12.7
Health ankles (seconds)	31.4 $\pm$ 5.1	31.3 $\pm$ 5.3

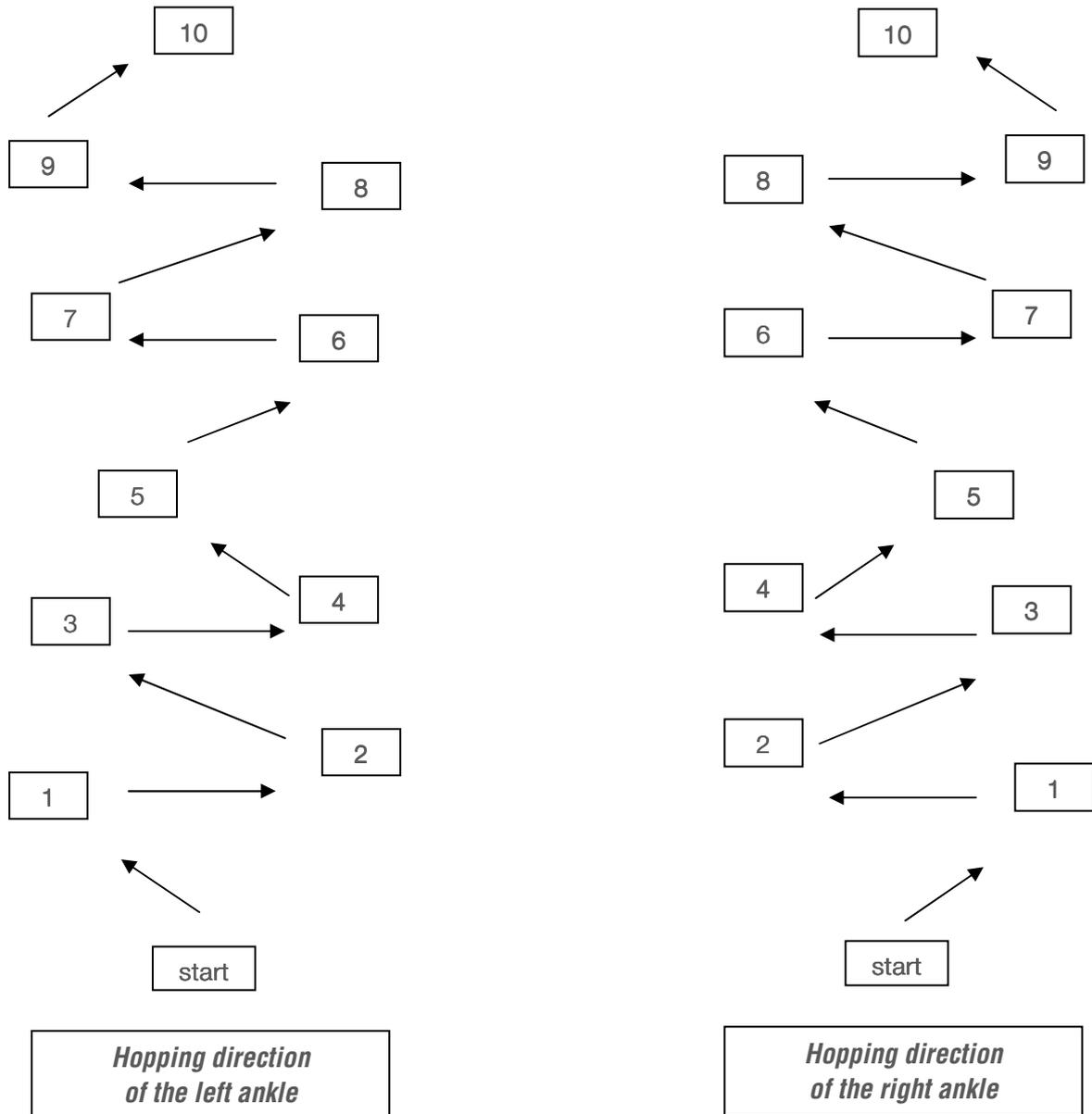


Figure 25. Layout with the hopping direction for left and right ankles

## **SPECIAL TESTS**

### **ULTRASOUND MEASUREMENT OF THE LATERAL ABDOMINAL WALL**

#### **Definition**

This test is used to assess the change of thickness of the lateral abdominal wall during abdominal hollowing. This provides information on the function of the core stabiliser transversus abdominis. The static muscle thickness at a given site can be measured to assess symmetry between sides and subjects.

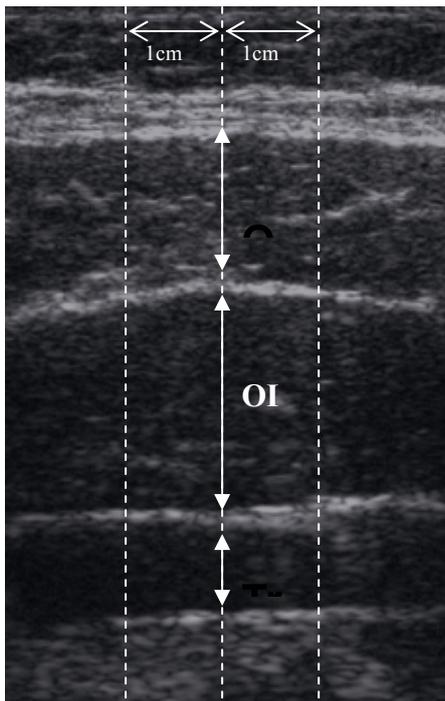
#### **Equipment required**

A real-time ultrasound scanner with a 12 MHz linear sound head is recommended. The ultrasound must be calibrated prior to use. The ultrasound needs a calliper function to measure the thickness of the 3 abdominal muscles. A plinth is required.

#### **Procedure**

The subject lies on a plinth. The transducer head is placed transversely 2.5 cm anterior to the mid-point between the ribs and the inferior border of the iliac crest. The medial edge of the transducer head is positioned approximately 10 cm from the midline. Once this position is attained it is clearly marked with indelible ink to ensure that the position on the sound head placement is accurate throughout testing. The thickest part of the transversus abdominis has previously been shown to lie between the iliac crest and the ribs<sup>(53)</sup>. This position allowed for simultaneous imaging of the transversus abdominis, internal oblique and external oblique muscle<sup>(16;33;44)</sup>.

The subjects are positioned supine with the hips and knees flexed to 90° to ensure a neutral position of the lumbar spine and maximum relaxation of the abdominal muscles. The ultrasound placement is determined. The subjects should be instructed to relax their abdomen prior to freezing the ultrasound image. Once accurate visualisation of the 3 abdominal muscles (external oblique, internal oblique, and transversus abdominis) is obtained the image is frozen and measurements of the 3 lateral abdominal muscles are taken. Three thickness measures must be taken for each muscle (external oblique, internal oblique, transversus abdominis) at intervals 1 cm on either side, and including, the midline site (Figure 26). The 3 thickness values obtained for each muscle are then averaged and converted to millimetres using the calibration scale on each image. The thickness of the three abdominal muscles on both sides is recorded in millimetres (mm).



**Figure 26.** Ultrasound measurement of the lateral abdominal muscles.

The subject is then instructed to perform an abdominal hollowing maneuver by gently pulling the abdominal wall in towards the spine. The measurements are then repeated. This is repeated on both side.

### **Reliability**

The repeatability of ultrasound measurement of the thickness of the abdominal muscles has been established <sup>(16;33;44)</sup>. Critchley & Coutts <sup>(16)</sup> established intra-class correlation coefficients of  $R = 0.95$ ,  $0.98$  and  $0.94$  for the external oblique, internal oblique and transversus abdominis muscles, respectively. Further, Misuri <sup>(44)</sup> confirmed the high reproducibility of measuring abdominal muscle thickness with ultrasound. The relationship between the change in muscle thickness of the abdominal wall and muscle activity is curvilinear <sup>(33)</sup>. However, at a maximal voluntary contraction of less than 20-30% this relationship is linear and as such the change in muscle thickness can be directly related to the muscle activity of the muscle in question.

### **Normative data**

There are no normative data for abdominal hollowing within a sporting population.

### **AUTHORS' BIOGRAPHIES:**

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