Rehabilitation
Research Interest Group

Upper Extremity Testing: Shoulder Emphasis
Standard Operating Procedures

Contributing Institutions

Connecticut Children's

Seattle Children's

Children's Hospital of Atlanta

Children's Hospital of Philadelphia

Texas Children's Hospital

Nemours Children's Hospital

Scottish Rite for Children

Impulse Physical Therapy

University of Rochester Medical Center

Riley Children's

Last Modified: December 10th, 2024

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Section II: Background

To further understand and optimize care for the youth athlete, PRiSM formed the Rehabilitation Research Interest Group (RIG). This collaborative group of researchers and clinicians seek to improve outcomes across all areas of pediatric sports medicine. Identifying the significant lack in consensus on post-operative shoulder Return to Sport (RTS) testing, the Rehab RIG formed a subcommittee of clinical experts with the intention of developing standards and recommendations that would be clinically useful for all rehabilitation professionals.

Throughout the course of 2024, workgroup members developed a standardized clinical protocol to best evaluate patients following shoulder stabilization procedures. Components of this protocol may serve as a guide for clinical evaluation and assist the interdisciplinary healthcare team with RTS decision making. The establishment of this standardized protocol has also provided the foundation for future multicenter clinical research using objective testing of the upper extremity.

The importance of using objective measures in assessing an athlete's readiness to RTS after an injury cannot be overstated. There continues to be a lack of standardization surrounding which objective measures should be utilized to clear athletes post-injury. This complexity is further magnified by various factors such as nature and location of the injury, biomechanical sport demands and level of participation. The challenge is especially pronounced in the context of upper extremity RTS testing in adolescent and pre-pubescent athletes. There is a gap in the literature on standardized testing, scoring, and normative values for these athletes which exacerbates the ambiguity surrounding RTS readiness. These young athletes have unique physiologic and development considerations that necessitate a specialized systemic approach for decision making.

Currently, most guidelines for upper extremity RTS are tailored to specific surgeries and patient populations, often neglecting adolescent and pre-pubescent athletes. Some recent data-driven efforts have proposed algorithms for specific scenarios, however, much of the available information on upper extremity RTS is based on clinical commentaries derived from expert opinions aimed at guiding clinical decision making.

The unique needs of these athletes, in particular adolescent and pre-pubescent individuals, underscore the urgency of future research, collaboration and education in the field of sports medicine. This standard operating procedure can serve as bases for systemic objective assessment to evaluate RTS readiness in adolescent and pre-pubescent populations. This will work towards a comprehensive understanding of the metrics required for accurate RTS decision making in an underserved population.

Section III: Range of Motion Measurement

Background

- The ability to differentiate and quantify ROM at the glenohumeral joint from other joints in the shoulder complex is important in diagnosing and treating many shoulder conditions – particularly in the overhead athlete.
- The methods of measuring glenohumeral motion requires the use of passive motion and careful stabilization of the scapula.
- Active shoulder motion is avoided because it results in synchronous motion throughout the shoulder complex making isolation of the glenohumeral joint difficult.

III.a Passive Glenohumeral Flexion Range of Motion

Testing Position

Place the patient in a supine position with the knees flexed to 90° and the hips flexed to 45° to flatten the lumbar spine. The shoulder should initially be placed at 0° of abduction, adduction, and rotation, full elbow extension to avoid limitations due to triceps long head tightness, and the palm of the hand facing the patient's body so that the forearm is in 0° of supination and pronation.

Goniometer Alignment

Fulcrum: Aligned with the lateral aspect of the greater tubercle
Proximal Arm: Aligned parallel to the midaxillary line of the thorax
Distal Arm: Aligned with the lateral midline of the humerus with reference to the lateral epicondyle

Stabilization Procedure

Place the heel of the hand over the lateral border of the scapula to prevent upward rotation, elevation, and posterior tilting of the scapula. The end of glenohumeral shoulder flexion range of motion occurs when the clinician starts to feel the lateral border of the scapula moving into their stabilization hand.

III.b Passive Glenohumeral Abduction Range of Motion

Testing Position

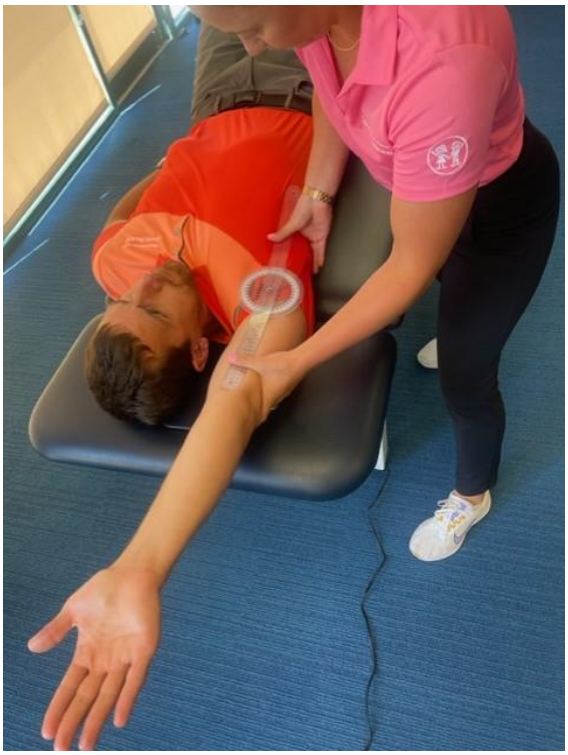
Place the patient in a supine position with the knees flexed to 90° and the hips flexed to 45° to flatten the lumbar spine. The shoulder should initially be placed at 0° of abduction, adduction, and flexion. The patients shoulder will be externally rotated with the palm of the hand facing up towards the ceiling so that contact between the greater tubercle of the humerus and superior glenoid fossa or acromion process does not restrict motion. The elbow is fully extended to avoid limitations due to triceps long head tightness.

Goniometer Alignment

Fulcrum: Aligned with the anterior aspect of the acromion process
Proximal Arm: Aligned parallel to the midline of the sternum
Distal Arm: Aligned with the anterior midline of the humerus

Stabilization Procedure

The clinician will place the heel of their hand over the lateral border of the scapula to prevent upward rotation and elevation of the scapula. The end of glenohumeral abduction range of motion occurs when the clinician starts to feel the lateral border of the scapula moving into their stabilization hand.



III.c Passive Glenohumeral Horizontal Adduction Range of Motion Screen

Testing Position

Place the patient in a supine position with the knees flexed to 90° and the hips flexed to 45° to flatten the lumbar spine. The shoulder should initially be placed at 90° of flexion and 0° of horizontal shoulder abduction/adduction. The elbow is placed at 90° of flexion with the palm of the hand facing in the caudal direction.

Stabilization Procedure

The clinician will place the heel of their hand over the lateral border of the scapula to prevent upward rotation and protraction of the scapula. The end of glenohumeral horizontal adduction range of motion occurs when the clinician starts to feel the lateral border of the scapula moving into their stabilization hand.

Measurement Screen

Ensure the patient's head is in a neutral position and observe the translation of the olecranon process of the elbow in comparison to the bridge of the patient's nose. If the patient's olecranon meets or surpasses the patient's midline at the bridge of the nose, the range of motion is considered normal. If the patient's olecranon does not meet or surpass the patient's midline at the bridge of the nose, the range of motion is considered limited.

III.d Passive Glenohumeral External Range of Motion

Testing Position

Place the patient in a supine position with the knees flexed to 90° and the hips flexed to 45° to flatten the lumbar spine. The shoulder should initially be placed at 90° of abduction, 0° of rotation, and propped up so that the humerus is level with the acromion process. The elbow should be placed at 90° of elbow flexion and forearm in neutral pronation/supination.

Goniometer Alignment

Fulcrum: Aligned with olecranon process

Proximal Arm: Aligned perpendicular to the floor
Distal Arm: Aligned with ulnar styloid process

Stabilization Procedure

The clinician will place their thumb over the lateral border of the scapula or the coracoid process of the scapula to prevent posterior tilting and retraction of the scapula. The end of passive glenohumeral shoulder external range of motion occurs when the clinician feels movement at the coracoid process. The arm should be maintained in 90° of shoulder abduction and 90° of elbow flexion during the motion.

III.e Passive Glenohumeral Internal Range of Motion

Testing Position

Place the patient in a supine position with the knees flexed to 90° and the hips flexed to 45° to flatten the lumbar spine. The shoulder should initially be placed at 90° of abduction, 0° of rotation, and propped up so that the humerus is level with the acromion process. The elbow should be placed at 90° of elbow flexion and the forearm in neutral supination/pronation.

Goniometer Alignment

Fulcrum: Aligned with olecranon process
Proximal Arm: Aligned perpendicular to the floor
Distal Arm: Aligned with ulnar styloid process

Stabilization Procedure

The clinician will place their thumb over the lateral border of the scapula or the coracoid process of the scapula to prevent anterior tilting and protraction of the scapula. The end of passive glenohumeral shoulder internal range of

motion occurs when the clinician must provide external stabilizing force to the coracoid process to overcome movement at the scapula. The arm should be maintained in 90° of shoulder abduction and 90° of elbow flexion during the motion.

Section IV: Strength Assessment

IV.a: Isometric Handheld Dynamometry

Background: General Recommendations[1,2]

- Use appropriate bracing techniques and body mechanics when performing HHD testing to prevent the patient from overpowering you.
- To ensure proper patient stabilization, the therapist can stabilize the patient, stabilizing belt or strap can be used, or the patient can hold the edge of the table or chair.
- Standardize your setup using the instructions below for reliable and accurate results.
- Test the uninvolved side first to build patient confidence and familiarity before assessing the involved side.
- Allow one practice trial on each side.
- Perform 2 maximal effort test trials.
- Each trial should be 3-5 seconds long.
- Record the average of the test trials.
- For accuracy, the maximal effort trials should be within 10% of each other.
- Note the location and intensity of any pain experienced by the patient during the assessment.

Shoulder Flexion

- Patient Position: Supine with the tested arm in 90° of shoulder flexion, forearm pronated, and elbow extended. Transducer is placed just proximal to the wrist crease.
- Examiner Position: Standing at the head of the table superior the arm being tested.

Shoulder Scaption

- Patient Position: Supine and the tested arm is in 90° of shoulder scaption (40° anterior to frontal plane) and externally rotated (thumb pointed up). The transducer is placed just proximal to the wrist crease.
- Examiner Position: Standing at the head of the table superior the arm being tested.

Shoulder Abduction

- Patient Position: Supine with the tested arm in 90° of shoulder abduction and neutral shoulder rotation. The transducer is placed just proximal to the wrist crease.
- Examiner Position: Standing at the head of the table superior the arm being tested.

Shoulder Extension

- Patient Position: Supine with the shoulder flexed to 90°. The transducer is placed just proximal to the wrist crease.
- Examiner Position: Standing at the side of the table inferior the arm being tested.

Shoulder External Rotation in Neutral

- Patient Position: Supine with shoulder in neutral rotation and elbow flexed to 90 degrees. The transducer is placed just proximal to the wrist crease on the dorsal side.
- Examiner Position: Standing at the side of the table on the same side as the arm being tested.

Shoulder External Rotation at 90°

- Patient Position: Supine with shoulder in 90 degrees of abduction and neutral rotation. The elbow is flexed to 90 degrees. The transducer is placed just proximal to the wrist crease on the dorsal side.

- Examiner Position: Standing at the head of table, superior to the arm being tested.

Alternate Patient Position:

- Sitting with back against the wall and shoulder in 90 degrees of abduction and 90 degrees of external rotation. The elbow is flexed to 90 degrees. The transducer is placed between the wall and just proximal to the wrist crease on the dorsal side.
- Examiner Position: Standing next to the patient, holding the dynamometer.

Shoulder Internal Rotation in Neutral

- Patient Position: Supine with shoulder and forearm in neutral rotation. The elbow is flexed to 90 degrees. The transducer is placed just proximal to the wrist crease on the palmar side.
- Examiner Position: Standing at the side of the table on the opposite side as the arm being tested.

Shoulder Internal Rotation at 90°

- Patient Position: Supine with shoulder in neutral rotation and 90 degrees of abduction. The elbow flexed to 90 degrees. The transducer is placed just proximal to the wrist crease on the palmer side.
- Examiner Position: Standing at the side of the table inferior the arm being tested.

Alternate Patient Position:

- Patient Position: Sitting facing the wall with shoulder in 90 degrees of abduction and 90 degrees of external rotation. The elbow is flexed to 90 degrees. The transducer is placed between the wall and just proximal to the wrist crease on the palmar side.

- Examiner position: Standing next to the patient, holding the dynamometer.

Middle Trapezius (Prone T)

- Patient Position: Prone with elbow is extended, shoulder abducted to 90 degrees, and shoulder externally rotated (thumb pointed up). The transducer is placed just proximal to the wrist crease.
- Examiner Position: Standing at the side of the table inferior the arm being tested.

Lower Trapezius (Prone Y)

- Patient Position: Prone with elbow extended, shoulder abducted to 120°, and shoulder externally rotated (thumb pointed up). The transducer is placed just proximal to the wrist crease.
- Examiner Position: Standing at the side of the table inferior the arm being tested.

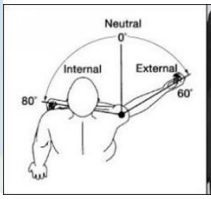
IV.b: Isokinetic Dynamometry

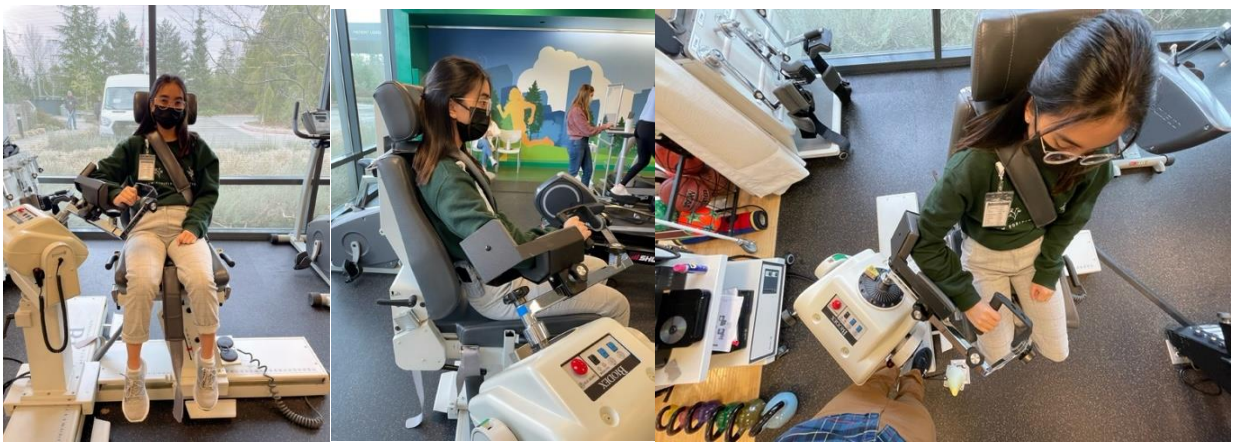
Background:

Isokinetic strength testing expands on the information collected with traditional isometric strength testing. Unfortunately, there are highly variable methods used when testing upper extremity isokinetic strength in the available literature. The goal of this section will be to standardize a protocol of isokinetic testing that is safe, evidenced based, clinically meaningful, and repeatable across all common isokinetic machines. Although many planes of motion may be tested with an isokinetic dynamometer, this protocol will only include external rotation (ER) and internal rotation (IR) as they are frequently studied and clinically applicable.

Testing Position

Patient posture and shoulder position both play a significant role in muscle orientation, test reliability, and patient comfort. Although many overhead athletes require significant shoulder stability in 90° of abduction and 90° of external rotation (ER), this position may not be tolerated by all patients following shoulder stabilization procedures. A systematic review outlining the influence position has on the reliability of isokinetic shoulder testing deemed a seated position with 40°-45° of shoulder abduction in the scapular plane was the most reliable for IR and ER strength assessment.[3] This position includes a 90° angle between the trunk and thighs, strap stabilization for the torso and legs, and contralateral upper extremity grip support for additional stabilization. The upper extremity being tested should be elevated to 40°-45° in the scapular plane. The range of motion for testing should encompass the full available rotational arc of the shoulder.





Procedure

The patient should be positioned in short sitting with their trunk strap-stabilized. Upper extremity positioning should be elevated to 40° in the scapular plane, as described above. Elbow positioning should be stabilized at 90° of flexion and neutral forearm rotation. Patients will move through available ER and IR AROM to determine the limits of testing range.

Isokinetic testing procedures include speed set at 180°/s[4], one familiarization trial (five repetitions), and two test trials (10 repetitions) with 60 seconds of rest between test trials. Verbal cueing for the patient to "push and pull as hard and fast as possible" are to be given. The uninvolved extremity is to be tested first, followed by the involved extremity.

IV.c: Grip Strength

Background[5-7]

Grip strength has found to have a strong, positive correlation with whole-body muscle strength and weakness. This is in addition to a correlation to male gender (after age 12), age, height, and weight. Comparing grip strength to age and gender norms can be helpful proxy for a patient's overall strength, directing interventions and recommendations.

Male and female adolescents test similarly until approximately age 12, according to most studies, when males' grip strength rate of increase begin to accelerate. Of note, right-hand dominance tends to result in greater right hand grip strength, while left-hand dominance tends to produce similar strength measures bilaterally.

Table 1. Number of participants, grip strength values for the dominant and non-dominant hands, height and weight, according to age and gender.

Age (yr)	Boys					Girls				
	n	Dominant (kg)	Non-dominant (kg)	Height (cm)	Weight (kg)	n	Dominant (kg)	Non-dominant (kg)	Height (cm)	Weight (kg)
	mean (SD) range					mean (SD) range				
4	124	5.7 (2) 1 to 12	5.3 (2) 2 to 10	111 (5) 100 to 126	19 (3) 15 to 26	109	5.1 (2) 1 to 11	4.7 (2) 2 to 10	111 (5) 100 to 126	19 (3) 13 to 29
5	102	7.5 (3) 2 to 14	6.8 (3) 3 to 14	117 (6) 103 to 138	22 (3) 15 to 30	105	6.7 (2) 2 to 15	6.0 (2) 1 to 12	118 (6) 102 to 131	22 (3) 15 to 32
6	123	10.2 (3) 5 to 18	9.4 (3) 4 to 17	125 (5) 111 to 139	25 (4) 17 to 44	108	9.0 (3) 3 to 18	8.3 (3) 2 to 16	124 (6) 100 to 137	25 (4) 16 to 39
7	104	13.0 (4) 7 to 21	12.0 (3) 5 to 19	131 (6) 116 to 145	28 (5) 20 to 54	98	12.9 (3) 7 to 21	11.9 (3) 5 to 18	131 (6) 113 to 141	29 (5) 17 to 40
8	113	15.9 (4) 8 to 25	14.6 (3) 8 to 23	139 (6) 124 to 155	32 (6) 23 to 55	118	14.4 (3) 8 to 22	13.1 (3) 7 to 21	136 (6) 122 to 151	31 (6) 20 to 49
9	116	18.2 (4) 10 to 29	16.8 (4) 8 to 33	142 (6) 126 to 162	36 (7) 25 to 60	119	16.7 (3) 9 to 26	15.1 (3) 7 to 23	141 (5) 126 to 154	35 (7) 24 to 53
10	109	19.6 (2) 12 to 29	18.1 (3) 9 to 28	147 (7) 129 to 161	38 (7) 26 to 65	103	19.1 (4) 9 to 29	17.2 (4) 8 to 29	149 (7) 132 to 167	41 (8) 25 to 63
11	113	22.0 (5) 9 to 35	20.6 (4) 8 to 33	154 (8) 134 to 172	43 (10) 27 to 74	113	20.6 (4) 10 to 35	19.1 (4) 11 to 30	154 (8) 135 to 181	44 (9) 28 to 79
12	96	24.7 (5) 13 to 36	22.9 (5) 13 to 35	159 (9) 140 to 180	48 (10) 30 to 73	106	24.2 (5) 15 to 39	22.3 (4) 13 to 33	160 (6) 144 to 178	48 (11) 32 to 110
13	66	28.2 (6) 17 to 45	25.8 (6) 17 to 42	166 (9) 150 to 189	52 (10) 39 to 85	97	26.4 (5) 14 to 39	24.5 (4) 17 to 36	163 (7) 138 to 176	49 (8) 33 to 89
14	46	36.0 (7) 24 to 51	33.5 (7) 22 to 51	175 (8) 155 to 193	60 (11) 38 to 89	53	29.1 (5) 16 to 43	26.6 (5) 15 to 36	169 (6) 157 to 183	55 (10) 42 to 103

Ploegmakers, 2013[8]

Procedure

Use the Jamar dynamometer or similar device. The patient sits with the shoulder adducted, elbow flexed to 90 degrees, and wrist in a neutral position. The Jamar dynamometer is set to the "2" position. The patient squeezes with verbal encouragement for approximately 5 seconds. Repeat the effort and use the mean over 2-3 trials.

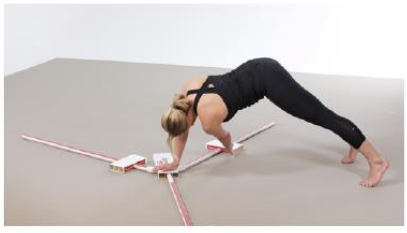
Section V: Functional Testing

V.a: Upper Quarter Y-Balance (UQ-YBAL)

Background

The Upper Quarter Y-Balance Test is a functional test for combined stability and motor control performed in the push up position and involves a maximal reach in directions (relative to stance arm): medial, inferolateral, and superolateral. The test requires shoulder girdle and core stability, as well as adequate shoulder and thoracic mobility in the closed chain. It can be used as a test of symmetry and/or restoration of function after an injury[9], using the uninjured limb as a reference for normal.

Medial Reach



Inferolateral Reach

Superolateral Reach

Several studies[9,10] indicate it is a valid and reliable test to measure changes to upper body stability or mobility in adolescents age 10 and older. While it is reliable in younger adolescents, reliability improves with older adolescents and therefore care should be taken to ensure younger patients put forth full concentration and effort to maximize its usefulness. Specifically, 16 years of age and above has excellent reliability, while younger ages have moderate to good reliability. It has statistically meaningful correlation to other closed chain measures of core and upper extremity stability,

namely the Closed Kinetic Chain Upper Extremity Stability Test (CKCUEST) (p=0.02), push-ups (p=0.02), the Lateral Trunk Endurance Test (p=0.01 - 0.04), or side bridge/side plank.

Performance is typically lower in at least one direction in those with current injuries or a history of upper body injuries, though the specific direction varies. Some research found lower scores in the superolateral reach direction in those with previous shoulder injuries, though it is unclear if this is consistent with various locations and types of previous injuries. Therefore, lower overall composite score may be the most helpful metric in determining asymmetries between limbs, or differences compared to a healthy population. Males and females do not score statistically different when normalized by arm length, and left and right sides also score similarly and can be compared.

Table 2. Upper Quarter Y Balance test performance (% arm length) by age group and sex.

Age group	10–11 years ($N = 56$)		12–13 years ($N = 175$)		14–15 years ($N = 218$)		16–17 years ($N = 216$)	
Sex	f ($n = 35$)	m ($n = 21$)	f ($n = 91$)	m ($n = 84$)	f ($n = 88$)	m ($n = 130$)	f ($n = 111$)	m ($n = 105$)
Right arm reach								
Medial	100.7 (10.9)	100.1 (7.9)	95.7 (11.7)	92.9 (10.3)	98.3 (10.3)	104.1 (12.3)	96.6 (14.5)	96.5 (15.6)
Inferolateral	98.4 (17.4)	95.4 (14.5)	88.4 (13.7)	86.0 (16.3)	84.1 (13.1)	97.7 (15.8)	85.2 (15.8)	92.0 (20.6)
Superolateral	73.0 (15.2)	69.7 (17.1)	69.0 (12.5)	63.0 (12.9)	70.7 (14.4)	76.2 (13.5)	72.1 (15.5)	76.8 (16.0)
Composite score	90.7 (12.9)	88.4 (11.9)	84.5 (11.1)	80.5 (10.9)	84.3 (10.8)	92.6 (11.9)	84.6 (12.3)	88.4 (12.8)
Left arm reach								
Medial	98.2 (9.3)	99.5 (9.0)	95.8 (11.0)	93.1 (11.1)	96.9 (9.3)	103.7 (11.8)	94.9 (13.0)	95.8 (15.5)
Inferolateral	96.6 (14.6)	97.0 (14.4)	88.8 (14.7)	85.9 (14.5)	83.1 (12.5)	95.7 (15.8)	84.9 (15.6)	91.1 (21.0)
Superolateral	71.4 (12.8)	70.7 (15.9)	67.3 (12.0)	60.9 (13.0)	69.2 (14.2)	73.7 (14.0)	70.4 (15.4)	74.6 (16.4)
Composite score	88.7 (11.0)	89.1 (11.9)	84.0 (11.1)	80.1 (11.4)	83.1 (10.1)	91.1 (11.9)	83.4 (11.9)	87.2 (13.0)

Schwiertz et al, 2021[11]

Testing Position

The patient's arm length is measured in standing from the spinous process of C7 vertebra to the distal tip of the right middle finger with the arm in 90° of abduction. The patient assumes a push up position with all fingers, including the thumb, lateral to the line on the Y-Balance Test kit. The shoulders begin directly above the stance hand, and the feet are perpendicular to the test kit approximately shoulder width apart. Once the patient lifts the reaching hand, they push the reach indicators as far as possible in the following sequence without returning the hand to the ground: medial, inferolateral, superolateral. The patient should not lift or move their feet, touches only the front edge of the reach indicator, and must return to the starting position with control. If the patient loses balance they must restart the sequence. They are given 2 practice trials, followed by 3 reach trials. If there are failed trials due to faults, they are allowed up to 6 trials, and the maximum reach distance is taken for each direction. Faults include placing hand on top of reach indicator, touching the floor, lifting/moving their feet, shoving the reach indicator, or being unable to return to the starting position under control. It is not a fault if patient elevates or lowers their hips. Shoes are optional and noted.

Each individual reach direction distance can be then divided by the arm length to normalize, and then compared to above norms. Composite score is calculated by adding all three directions and dividing by the three times the arm length. Composite scores can be compared to norms to determine deficits in upper quarter mobility or stability.

V.b: Closed Kinetic Chain Upper Extremity Stability Test (CKCUEST)

Background

The Closed Kinetic Chain Upper Extremity Stability Test has been tested in many different populations and has been found to be reliable and valid for the upper extremity. Oliveria et al. (2017) found the CKUEST was reliable in adolescents with a mean age of 16.92 (n= 25)[12]. Westrick et al (2012) evaluated the UQ Y-balance and the CKCUEST and found limited evidence for convergent construct validity[9]. Tucci et al. (2014) found fair evidence for discriminated construct validity in patients with and without shoulder impingement. In the same study, they found cut off scores of 23 for females and 21 for males[13].

With the proposal of changing hand position, Tucci et al. (2017) investigated the kinematics and kinetic measurements among 3 different distances between hands, and they found that there were not kinematic or kinetic measurement difference among the 3 conditions[14]. Tucci et al. also reported the challenging requirements of the test that may not be suitable for initial or mild-level rehabilitation[14].

Testing Position

Patient assumes a push-up position with hands positioned on a marking 36" apart. Patients are to lift one hand and touch it to the other hand, resulting in a shift in weight towards the static hand, with the objective of achieving as many touches as possible in 15 seconds. Each successful touch is recorded.

If they are unable to perform two successful repetitions due to their arm span, not due to weakness, the distance between their hands should be reduced from the original 36" to the distance from C7-to-middle finger tip. There are no modifications to allow test to be performed on their knees for either sex.

Perform a submaximal warm-up before the actual test for practice and assessment of the patient's ability at the 36" width. Three test trials are performed and the maximum score is recorded. A rest period of 45 seconds should be given between trials to allow at least a minimum of 1:3 work:rest ratio.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V.c: Seated Single-Arm Shot Put Test

Background

This test is intended to isolate and measure the ability of the upper extremity unilaterally to produce max power output in a functional, open kinetic chain position.

Testing Position

The patient is positioned seated on the floor against the wall with their knees flexed to 90° and their back and head in a neutral position leaning against the wall. The patient is then instructed to hold a 6 lb. (~3kg) medicine ball in their uninvolved side at shoulder height. Their elbow is in no greater than 30° of abduction and the shoulder is resting at 0° of flexion. The patient's opposite arm is resting with their palm against their abdomen. The patient is then instructed to push the ball as far as possible in the horizontal direction and perform one submaximal and one maximal trial prior to testing for familiarization of testing procedures. The patient may receive additional instruction during the familiarization period and additional trials, if necessary, to ensure adequate form. The patient then performs 3 consecutive tests with a 30 second break in between trials. Repeat same procedure on the involved side.

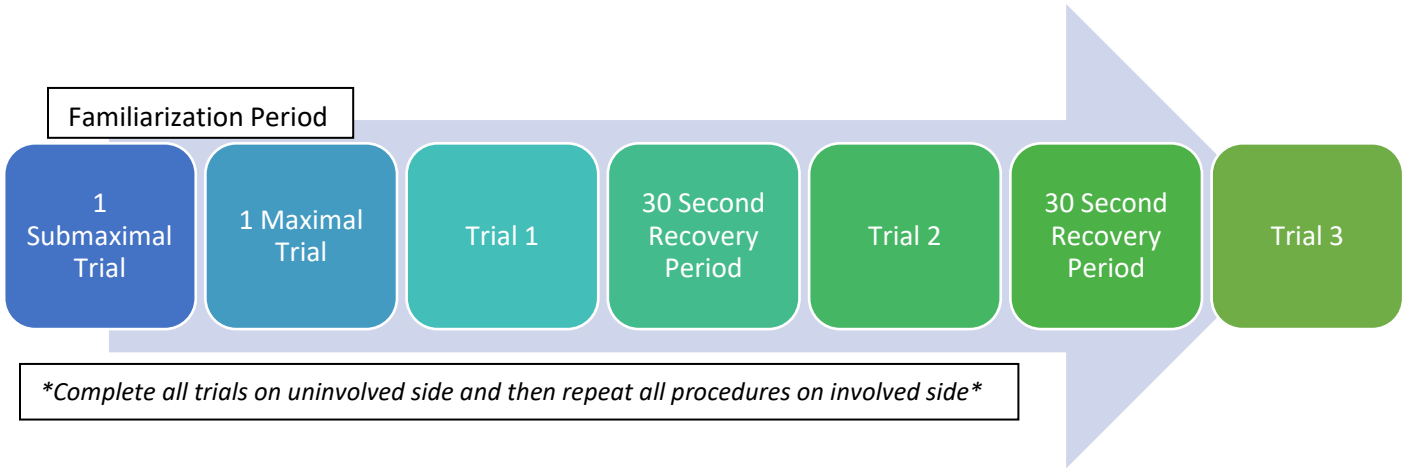
Figure 1 Starting Position

Figure 2: Release Position

Figure 3: Measurement Set up with Laser

Figure 4: Required Equipment

Testing Protocol



Scoring Protocol

- The clinician will stand an appropriate distance away to accurately visualize where the ball makes first contact with the ground. The clinician will then place a small piece of tape longitudinally on the floor to mark the spot. After all three trials have been collected on the uninvolved side, have the patient move just to the side so that their body does not impede the laser measurements. Using the laser, the clinician will line up the front of the laser with the end of the tape closest to the clinician and measure the distance from the tape to the spot on the wall where the patient was seated.
- Note: When using the laser, ensure to utilize the setting on the laser to measure distance from the front and not the back i.e. so that the measurement does not include the length of the laser device itself. (see photo above)
- If laser is not available, a tape measure can be used starting from the wall that the patient is supported against.

Scoring

- Average 3 trial scores
    - (Trial 1 + Trial 2 + Trial 3)/3 = Final Score
- LSI %
    - (Involved side final score/Uninvolved side final score)*100=LSI %
    - Recommended passing scores *(Riemann & Davies 2022)*[16]
        - If dominant arm is the involved side LSI % >103%
        - If non-dominant is the involved side LSI % >89%

V.d: The Athletic Shoulder Test (ASH)

Background:

The Athletic Shoulder Test (ASH)[17] test was first described by Ashworth et al in 2018. It is used to measure the isometric strength of the shoulder joint. It involves lying prone on a force platform and pushing with both arms at three different angles of shoulder abduction: 180° (I-position), 135° (Y-position), and 90° (T-position). The test measures the net peak force (NPF) and the highest NPF achieved in any trial (peak NPF) for each position. The test has excellent reliability and can be used to monitor the neuromuscular performance of the shoulder girdle, as well as detect any strength asymmetries or deficits that may increase the risk of injury or impair performance.

Testing:

Testing parameters: A standardized warmup is completed with 2 submaximal 80-90% efforts completed in each position. One 3 second isometric was performed on both sides, in each of the 3 positions, with 20 seconds rest between positions.

- Equipment: 4-inch foam block and force platform (recommended to be at 1,000 Hz sampling frequency).
- Position: Prone with head on foam and hand resting on force plate/platform in 180, 135, or 90° of shoulder abduction. The contralateral hand is placed behind the back.
- Cues: Verbal encouragement during test with instructions to push as hard and fast as possible and sustain for the 3 seconds. No countermovement was allowed.

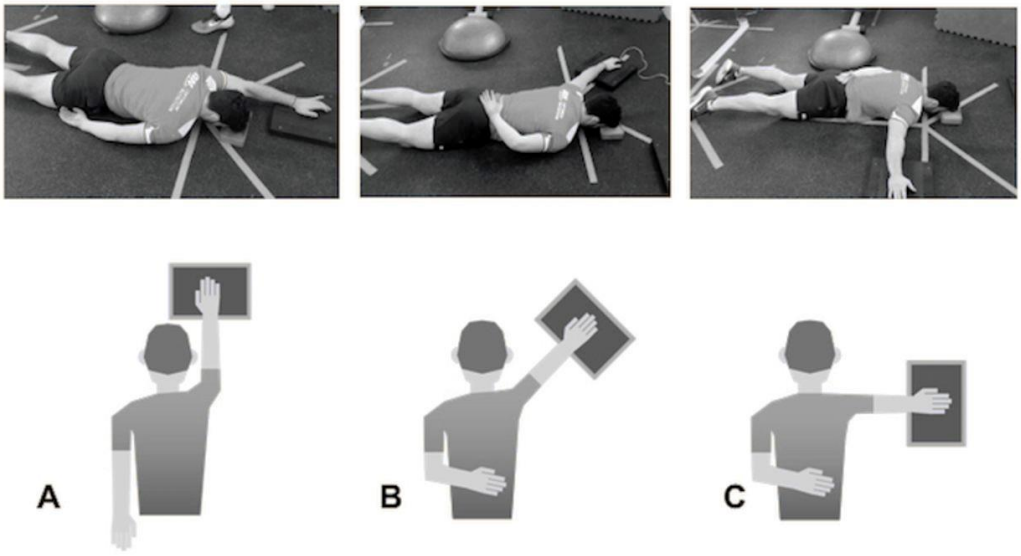
Psychometric Properties:

- Interday reliability: ICC = 0.94-0.98
- SEM: 4.8-10.8 N
- Interday error in all positions: (CV 5.0-9.9%), except non-dominant arm I-position (CV 11.3%)
- MDC: 13.2-25.9N

Normative data: No normative data is available in an adolescent population.

Asymmetries in throwing athletes:
In the 2022 IJSPT paper by Trunt et al, thirty-five healthy pitchers (19.7 ± 1.8 years) demonstrated significantly greater isometric shoulder strength at the 90° and 135° abduction positions with the throwing arm compared to the non-throwing arm, but this was not correlated to fastball velocity.[18]

Modified ASH Test:
The Modified-Athletic Shoulder Test (M-AST) utilizes a handheld dynamometer, offering a reliable, cost-effective, and more accessible alternative to the traditional ASH Test[19,20]. The setup and performance is the same. Its validity and reliability were confirmed through strong concordance with the ASH Test (ICC = 0.86-0.97)[21]. However, inter-session reliability showed variability (ICC = 0.643-0.923). The M-AST is practical for assessing status in upper limb athletes, but it requires familiarization trials for accuracy.



V.e Prone Medicine Ball Drop Test at 90° Shoulder Abduction (PMBDT 90°) [16,22,23]

Background

The Prone Medicine Ball Drop Test at 90° shoulder abduction (PMBDT 90°)[16], also known as the ball drop test[22] or the prone T ball drop test[23], evaluates dynamic stability, ability to move the upper extremity quickly, and endurance of the shoulder complex. This test is largely focused on posterior glenohumeral musculature.

Testing Position

Testing procedures are as follows:

1. Participant is positioned in prone on plinth with testing shoulder abducted to 90° with full elbow extension and with forearm supinated (palm to floor) as shown in Figure 1.
2. The non-testing arm should be supported over the opposite side of the table (or completely off the table) and participants were instructed not to grasp the table for support during testing.
3. Place a mobile stool under the participant's testing arm to catch the medicine ball if the ball is dropped.
4. Instruct the participant to maintain shoulder abduction to 90°.

5. The participant drops and catches a .91 kg (2 lb.) medicine ball as many times as possible for 30 seconds.
6. One trial is performed on each arm with a 30 second rest period between each trial.
7. The total number of catches recorded during the 30 second trial serves as the performance outcome metric. Limb symmetry indices (LSI) are calculated ([dominant/nondominant] * 100).

Wilk et al report a satisfactory score on the PMBDT 90° is considered a limb symmetry index of ≥110% of the dominant extremity compared to the non-dominant extremity.[22]

This test can also be completed in 90° of shoulder abduction and 90° of elbow flexion, also known as the prone medicine ball drop test at 90° shoulder abduction/90° elbow flexion (PMBDT 90°-90°). The testing position is shown in Figure 2. The general testing procedures are the same as for the PMBDT 90°.

Overall, the PMBDT 90° has excellent relative reliability but the absolute reliability is considered just beyond acceptable levels. There is a larger chance of random error with this test when compared to other upper extremity functional tests. There are challenges to clinical utility with current version due to concerns with reliability however there are currently limited functional testing options isolating posterior glenohumeral musculature. PMBDT 90° revealed slightly higher reliability compared to PMBDT 90°-90°. Current research is being completed to determine if two trials of 15 seconds is superior to avoid the effects of grip fatigue.

Figure 1: Prone Medicine Ball Drop Test at 90° shoulder abduction

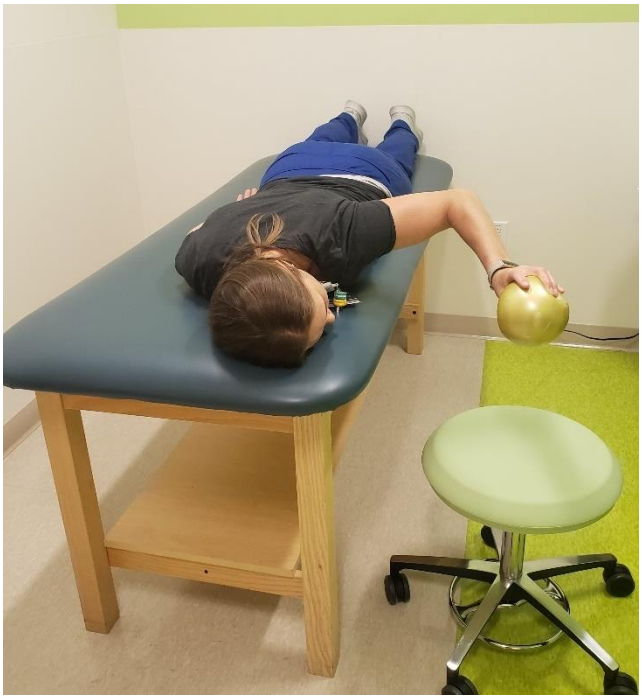


Figure 2: Prone Medicine Ball Drop Test at 90° shoulder abduction/90° elbow flexion

V.f 90° Wall Throws Test[16]/Wall Throws Test at 90°/90°[22]

Background

The 90° Wall Throws Test, also known as the Wall Throws Test at 90°/90°, evaluates endurance, strength, mechanics, and proprioception of the upper extremity. This test was designed for the overhead throwing athlete.

Testing Position

Testing procedures are as follows:

1. The participant is positioned standing in an open doorway or against the edge of a wall.
2. The testing shoulder is positioned in 90° of shoulder abduction with elbow flexed to 90° with forearm supinated (palm towards wall) as shown in Figure 1.
3. The participant throws and catches a .91 kg (2 lb.) medicine ball against the wall as many times as possible for 30 seconds as shown in Figure 2.
4. One trial is performed on each arm with a 30 second rest period between each trial.
5. The total number of catches recorded during the 30 second trial serves as the performance outcome metric. Limb symmetry indices (LSI) are calculated ([dominant/nondominant] * 100).

Wilk et al report a satisfactory score in the overhead throwing athlete is a limb symmetry index of ≥112% on the dominant extremity compared to the non-dominant extremity.[22] Higher level athletes (professional baseball players) typically demonstrate a higher dominant-non-dominant difference when compared to high school or collegiate athletes.[22] Despite this finding, ratios between dominant and non-dominant sides remain consistent despite level of play.

This functional test can be modified to a half-kneeling position, also known as the Half-Kneeling Medicine Ball Rebound Test (HKMBRT)[16], to eliminate compensations from the lower extremities. Testing positions are shown in Figures 3 and 4. During this version of the test, the non-testing side leg is forward with the non-testing hand placed on the ipsilateral knee. The HKMBRT is considered to have excellent reliability and is considered to assess the anterior musculature.

Figure 1: Start position (90° Wall Throws Test)

Figure 2: Mid position (90° Wall Throws Test)

Figure 3: Start position (HKMBRT)

Figure 4: Mid position (HKMBRT)

V.g Prone Shoulder Endurance Test (PSET)

Background[24]*:*

Muscular endurance is a key requirement to maintain muscle function throughout a high volume activity. Arm fatigue has been identified as a common risk factor for shoulder and elbow injuries in youth baseball pitchers with 32% aged 9-12 reporting shoulder pain during their season. The posterior shoulder endurance test (PSET) was initially studied on adolescent baseball players age (16yo+/- 2 years).

Testing Procedures:

1. Patient will be prone and complete prone horizontal abduction at 90° with external rotation (thumb up).
2. 2% body weight is utilized- rounded to nearest half pound and held in hand.
3. Cadence: 30 beats per minute metronome used, with a pause held at the top of the movement until the next beat is heard.
4. Record total repetitions performed. Test is complete when:
    a. fatigue/unable to complete more reps.
    b. Inability to hold arm at the top of the arc for 1 second.
    c. Unavoidable compensatory patterns, i.e. elevation of upper torso.

Scoring:

- Limb symmetry index- 10% increase in reps on the dominant compared to the non-dominant side
- Test-retest reliability ICC: 0.85
- Standard error of measurement: 3 repetitions
- Minimal detectable change: 4 repetitions

Section VI: Patient Reported Outcome Measures

VI.a Pain, Disability, and Function

Disabilities of the Arm, Shoulder and Hand (QuickDASH)[25,26]

Description of scale: The QuickDASH is valid and reliable outcome measure for patients with an upper extremity musculoskeletal disorder or pain. The QuickDASH is a shortened version developed from the DASH (Disabilities of the arm, shoulder, and hand) and is appropriate for an athlete or non-athlete with an optional sport specific subsection.
Appropriate Populations:

- Ages 8 and up
- Sex: males and females
- Diagnoses: musculoskeletal diagnoses for the shoulder, elbow or hand (UE)
- Can be translated into 30 different languages

Administration and Scoring

Administration: Less than 10 minutes, patient reported, paper or electronic

Items: two parts, 15 items total, with an optional additional sport subsection of 4 items

QuickDASH disability/symptom section- 11 items

scores between 1-5 for each question

1= no difficulty with task

5=unable to complete

QuickDASH Sports and performing arts sub-section- 4 items

scores between 1-5 for each question

1= no difficulty with task

5=unable to complete

Scoring:

- Total score: 0-100 (can only skip 1 question in main section, and must answer all for sports subsection in order to get an accurate score)

  0= best score, no difficulty with tasks

  100= worst score, most difficulty or unable to complete any tasks
- Calculation: Main section and sports subsection are scored separately

  The sum of the scores is divided by the number of questions answered. Subtract by 1 and multiply by 25.

Psychometric properties

MCID: 15.91

Western Ontario Shoulder Instability Index (WOSI)[27]

Specifically designed to evaluate patients with shoulder instability. Categories include:

1. Physical symptoms (10 items)
2. Sports, recreation, work (4 items)
3. Pain (4 items)
4. Lifestyle (4 items)
5. Emotion (3 items)

Each category scored from 0 to 100 and summed together for an overall score range from 0 to 2100. Lower scores indicate better shoulder function.

Pediatric/Adolescent Shoulder Survey (PASS)[28]

Designed to assess outcomes of upper extremity treatment for pediatric or adolescent patients. This tool combines the concepts for shoulder pathology that are found in the DASH and WOSI scores. Word choice was created at a fourth-grade reading level. The PASS shows good internal reliability, concurrent validity, and discriminant validity in the pediatric age group.

American Shoulder and Elbow Surgeons Standardized Shoulder Assessment Form (ASES)[29]

Intended to measure functional limitations and pain of the shoulder. Includes a "pain" section and an "ADL" section, with scores ranging from 0-100. Higher scores indicate better shoulder conditions.

VI.b Psychological Readiness or Fear

The Shoulder Instability-Return to Sport after Injury (SIRSI) Scale[30]

The SIRSI measures psychological readiness to return to sport after traumatic shoulder instability. It asks 12 questions with subsections of emotions, risk-appraisal, and confidence in performance. The SIRSI is scores 0-100 with greater scores indicating high psychological readiness.

The Tampa Scale for Kinesiophobia (TSK)[31]

The TSK was developed to assess self-reported fear of movement. It consists of 17 questions, with lower scores indicating less kinesiophobia.

References

1. Fieseler G, Molitor T, Irlenbusch L, et al. Intrarater reliability of goniometry and hand-held dynamometry for shoulder and elbow examinations in female team handball athletes and asymptomatic volunteers. *Arch Orthop Trauma Surg*. Dec 2015;135(12):1719-26. doi:10.1007/s00402-015-2331-6
2. Chamorro C, Arancibia M, Trigo B, Arias-Poblete L, Jerez-Mayorga D. Absolute Reliability and Concurrent Validity of Hand-Held Dynamometry in Shoulder Rotator Strength Assessment: Systematic Review and Meta-Analysis. *Int J Environ Res Public Health*. Sep 3 2021;18(17)doi:10.3390/ijerph18179293
3. Edouard P, Samozino P, Julia M, et al. Reliability of isokinetic assessment of shoulder-rotator strength: a systematic review of the effect of position. *J Sport Rehabil*. Aug 2011;20(3):367-83. doi:10.1123/jsr.20.3.367
4. Mulligan IJ, Biddington WB, Barnhart BD, Ellenbecker TS. Isokinetic profile of shoulder internal and external rotators of high school aged baseball pitchers. *J Strength Cond Res*. Nov 2004;18(4):861-6. doi:10.1519/14633.1
5. Wind AE, Takken T, Helders PJ, Engelbert RH. Is grip strength a predictor for total muscle strength in healthy children, adolescents, and young adults? *Eur J Pediatr*. Mar 2010;169(3):281-7. doi:10.1007/s00431-009-1010-4
6. De Smet L, Vercammen A. Grip strength in children. *J Pediatr Orthop B*. Oct 2001;10(4):352-4.
7. Molenaar HM, Selles RW, Zuidam JM, Willemsen SP, Stam HJ, Hovius SE. Growth diagrams for grip strength in children. *Clin Orthop Relat Res*. Jan 2010;468(1):217-23. doi:10.1007/s11999-009-0881-z
8. Ploegmakers JJ, Hepping AM, Geertzen JH, Bulstra SK, Stevens M. Grip strength is strongly associated with height, weight and gender in childhood: a cross sectional study of 2241 children and adolescents providing reference values. *J Physiother*. Dec 2013;59(4):255-61. doi:10.1016/S1836-9553(13)70202-9
9. Westrick RB, Miller JM, Carow SD, Gerber JP. Exploration of the y-balance test for assessment of upper quarter closed kinetic chain performance. *Int J Sports Phys Ther*. Apr 2012;7(2):139-47.
10. Schwiertz G, Brueckner D, Schedler S, Kiss R, Muehlbauer T. Reliability and Minimal Detectable Change of the Upper Quarter Y-Balance Test in Healthy Adolescents Aged 12 to 17 Years. *Int J Sports Phys Ther*. Dec 2019;14(6):927-934.

11. Schwiertz G, Bauer J, Muehlbauer T. Upper Quarter Y Balance test performance: Normative values for healthy youth aged 10 to 17 years. *PLoS One*. 2021;16(6):e0253144. doi:10.1371/journal.pone.0253144
12. de Oliveira VM, Pitangui AC, Nascimento VY, da Silva HA, Dos Passos MH, de Araujo RC. Test-Retest Reliability of the Closed Kinetic Chain Upper Extremity Stability Test (Ckcuest) in Adolescents: Reliability of Ckcuest in Adolescents. *Int J Sports Phys Ther*. Feb 2017;12(1):125-132.
13. Tucci HT, Martins J, Sposito Gde C, Camarini PM, de Oliveira AS. Closed Kinetic Chain Upper Extremity Stability test (CKCUES test): a reliability study in persons with and without shoulder impingement syndrome. *BMC Musculoskelet Disord*. Jan 3 2014;15:1. doi:10.1186/1471-2474-15-1
14. Tucci HT, Felicio LR, McQuade KJ, Bevilaqua-Grossi D, Camarini PM, Oliveira AS. Biomechanical Analysis of the Closed Kinetic Chain Upper-Extremity Stability Test. *J Sport Rehabil*. Jan 2017;26(1):42-50. doi:10.1123/jsr.2015-0071
15. Callaway A, Peck J, Ellis S, Williams J. A randomised observational study of individualised variations in the start position of the closed-kinetic chain upper extremity stability test. *Phys Ther Sport*. Jan 2020;41:16-22. doi:10.1016/j.ptsp.2019.10.007
16. Riemann BL, Wilk KE, Davies GJ. Reliability of Upper Extremity Functional Performance Tests for Overhead Sports Activities. *Int J Sports Phys Ther*. 2023;V18(3):687-697. doi:10.26603/001c.74368
17. Ashworth B, Hogben P, Singh N, Tulloch L, Cohen DD. The Athletic Shoulder (ASH) test: reliability of a novel upper body isometric strength test in elite rugby players. *BMJ Open Sport Exerc Med*. 2018;4(1):e000365. doi:10.1136/bmjsem-2018-000365
18. Trunt A, Fisher BT, MacFadden LN. Athletic Shoulder Test Differences Exist Bilaterally in Healthy Pitchers. *Int J Sports Phys Ther*. 2022;17(4):715-723. doi:10.26603/001c.35722
19. Tooth C, Forthomme B, Croisier JL, Gofflot A, Bornheim S, Schwartz C. The Modified-Athletic Shoulder Test: Reliability and validity of a new on-field assessment tool. *Phys Ther Sport*. Nov 2022;58:8-15. doi:10.1016/j.ptsp.2022.08.003
20. Krolikowska A, Mika A, Plaskota B, et al. Reliability and Validity of the Athletic Shoulder (ASH) Test Performed Using Portable Isometric-Based Strength Training Device. *Biology (Basel)*. Apr 11 2022;11(4)doi:10.3390/biology11040577

21. Olds M, McLaine S, Magni N. Validity and Reliability of the Kinvent Handheld Dynamometer in the Athletic Shoulder Test. *J Sport Rehabil*. Sep 1 2023;32(7):764-772. doi:10.1123/jsr.2022-0444
22. Wilk KE, Bagwell MS, Davies GJ, Arrigo CA. Return to Sport Participation Criteria Following Shoulder Injury: A Clinical Commentary. *Int J Sports Phys Ther*. Aug 2020;15(4):624-642.
23. Barber P, Pontillo M, Bellm E, Davies G. Objective and subjective measures to guide upper extremity return to sport testing: A modified Delphi survey. *Phys Ther Sport*. Jul 2023;62:17-24. doi:10.1016/j.ptsp.2023.05.009
24. Moore SD, Uhl TL, Kibler WB. Improvements in shoulder endurance following a baseball-specific strengthening program in high school baseball players. *Sports Health*. May 2013;5(3):233-8. doi:10.1177/1941738113477604
25. Kennedy CA, Beaton DE, Smith P, et al. Measurement properties of the QuickDASH (disabilities of the arm, shoulder and hand) outcome measure and cross-cultural adaptations of the QuickDASH: a systematic review. *Qual Life Res*. Nov 2013;22(9):2509-47. doi:10.1007/s11136-013-0362-4
26. Franchignoni F, Vercelli S, Giordano A, Sartorio F, Bravini E, Ferriero G. Minimal clinically important difference of the disabilities of the arm, shoulder and hand outcome measure (DASH) and its shortened version (QuickDASH). *J Orthop Sports Phys Ther*. Jan 2014;44(1):30-9. doi:10.2519/jospt.2014.4893
27. Kirkley A, Griffin S, McLintock H, Ng L. The development and evaluation of a disease-specific quality of life measurement tool for shoulder instability. The Western Ontario Shoulder Instability Index (WOSI). *Am J Sports Med*. Nov-Dec 1998;26(6):764-72. doi:10.1177/03635465980260060501
28. Edmonds EW, Bastrom TP, Roocroft JH, Calandra-Young VA, Pennock AT. The Pediatric/Adolescent Shoulder Survey (PASS): A Reliable Youth Questionnaire With Discriminant Validity and Responsiveness to Change. *Orthop J Sports Med*. Mar 2017;5(3):2325967117698466. doi:10.1177/2325967117698466
29. Michener LA, McClure PW, Sennett BJ. American Shoulder and Elbow Surgeons Standardized Shoulder Assessment Form, patient self-report section: reliability, validity, and responsiveness. *J Shoulder Elbow Surg*. Nov-Dec 2002;11(6):587-94. doi:10.1067/mse.2002.127096
30. Gerometta A, Klouche S, Herman S, Lefevre N, Bohu Y. The Shoulder Instability-Return to Sport after Injury (SIRSI): a valid and reproducible scale to quantify psychological readiness to return to sport after traumatic shoulder

instability. *Knee Surg Sports Traumatol Arthrosc*. Jan 2018;26(1):203-211. doi:10.1007/s00167-017-4645-0
31. French DJ, France CR, Vigneau F, French JA, Evans RT. Fear of movement/(re)injury in chronic pain: a psychometric assessment of the original English version of the Tampa scale for kinesiophobia (TSK). *Pain*. Jan 2007;127(1-2):42-51. doi:10.1016/j.pain.2006.07.016