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MEDICAL EDUCATION ARTICLE

Physical examination of the shoulder joint—Part I: Supraspinatus rotator cuff muscle clinical testing

Yehia M.A-H. Marreez, MD, PhD,[a] Mitchell D. Forman, DO, FACR, FACP,[b] Suzanne R. Brown, MPH, PhD, PT[c]

From [a]Basic Medical Sciences, Touro University Nevada, NV; [b]Department of Primary Care, Touro University Nevada, NV; and [c]School of Physical Therapy, Touro University Nevada, NV.

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Clinical testing is an easy and inexpensive tool that provides an informative guide toward initial diagnosis for shoulder joint dysfunctions. Clinical tests can be a powerful aid toward a correct diagnosis or at the least narrowing the differential diagnosis. Family physicians with good understanding of the underlying basic science knowledge of the commonly used clinical tests will be better able to employ a systematic approach in the initial workup and be able to avoid mistakes and errors in patient care.

In this article, common clinical tests to differentiate the etiology of shoulder supraspinatus rotator cuff disorders are presented. The tests presented include the Neer impingement, the Hawkins-Kennedy, the Jobe (empty-can), the painful arc, and the drop-arm tests. This article shows the correct performance and positioning for all tests. Each test is presented with a rational analysis of the test concept, procedure, and clinical application integrated to the relevant underlying basic science.

Introduction

Patients presenting with shoulder manifestations can be diagnostically challenging, as the upper arm movements are the result of both concurrent and sequential movements in the glenohumeral, acromioclavicular, and sternoclavicular joints in addition to the scapulothoracic junction.[1] Shoulder movements are complex with subtle interactions between the 4 articulations and contributing muscles.[2] The glenohumeral joint with its wide-range motions is considered biomechanically less stable than other joints of the body.[3] A delicate balance between dynamic and static anatomic components maintains glenohumeral joint stability and overcomes the humeral head and glenoid fossa incongruity.[4] A key dynamic component of the shoulder is the structure and function of the rotator cuff muscles (supraspinatus, infraspinatus, teres minor, and subscapularis).[5]

Rotator cuff muscles are biomechanically positioned to resist glenohumeral shear between the humeral head and the glenoid fossa by generating compressive forces as a part of "concavity compression" mechanism that limits the number of biomechanical centers of the joint.[6] The differential diagnosis options of the shoulder complex include multiple pathologic lesions[3] with many involving the rotator cuff muscles. An appreciation of the underlying anatomy and biomechanics of the region would enhance a correct diagnosis.

Common clinical tests to differentiate the etiology of shoulder disorders are presented. The selected tests are divided into 2 parts: first, supraspinatus and second, other muscles of the rotator cuff. Supraspinatus muscle is the most frequently injured muscle among all other rotator cuff.[7] In this section, 5 tests are presented to clinically examine supraspinatus muscle: the Neer impingement,

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Corresponding author: Yehia M.A-H. Marreez, MD, PhD, Basic Medical Sciences, Touro University Nevada, 874 American Pacific Henderson, NV 89014.

E-mail address: yehia.marreez@tun.touro.edu.

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the Hawkins-Kennedy, the Jobe (empty-can), the painful arc, and the drop-arm tests.

The Neer impingement test

The Neer impingement test is used to generally detect subacromial impingement. It may also specifically indicate pathology of the rotator cuff or long head of biceps brachii tendon. As described by Neer,[8] the patient may stand or sit with the shoulder, elbow, and wrist resting in the anatomic position. Examiner stands lateral to the involved side stabilizing the posterior aspect of the shoulder with the palm while palpating the shoulder joint with the fingers of the same hand. The examiner's other hand grasps the patient's arm distal to the elbow joint. The testing procedure begins with the humerus moved into internal rotation, elbow extension, and forearm pronation. The examiner forcibly moves the extended arm upward causing the glenohumeral joint to forward flex to 180° as the scapula is stabilized by the other hand. A positive test is recorded if the patient experiences pain especially toward the end of motion (Figure 1).

Rationale

As a passive maneuver, the Neer test assesses the non-contractile elements involved in the movement. The internal rotation motion of the humerus in this test is hypothesized to have 3 possible effects. First, subscapularis muscle might be in a contracted position to maintain internal rotation. Second, all other rotator cuff muscles (supraspinatus, teres minor, and infraspinatus) may be in a position that allows support of humeral head stabilization during passive flexion of the humerus. The scapula stabilization by the examiner's hand is a crucial method to eliminate the role of scapular rhythm in forward flexion and elevation of the humerus.[8] With the scapula stabilized, rotator cuff muscles assisted by long tendon of biceps brachii should be the only muscles acting on the glenohumeral joint. Third, internal rotation places the greater tuberosity of the humerus, and consequently supraspinatus and biceps tendon, in close contact with the anteroinferior surface of acromion.[9] The close contact between the greater tuberosity of the humerus and acromion is augmented during the passive forward flexion phase of the Neer maneuver. Presumably, any pain elicited during the forward arc of motion reflects a possible pathology in any of the involved bony or ligamentous structures, supraspinatus or long head of biceps brachii muscles as a result of impingement of the involved structure.[10] This concept was partly confirmed in the cadaveric study of Valadie et al,[9] however, the hypothesized mechanism of pain production still needs reproduction in controlled studies.

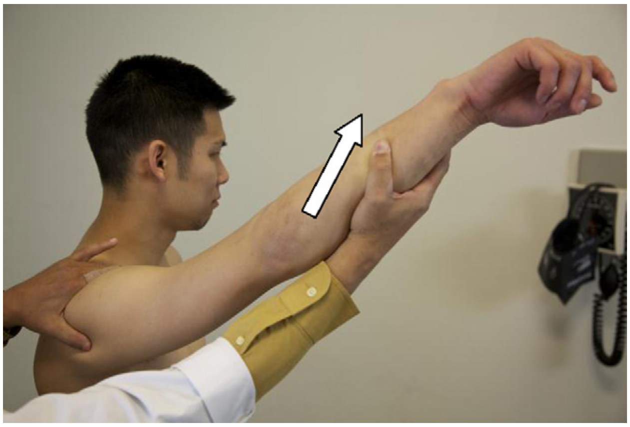

Figure 1 The Neer impingement test.

Modest sensitivity (68%) and specificity (68%) were reported in a validation study of the Neer test.[11] However, good sensitivity at 89%[12] and 79%[13] but poor specificity at 31%[12] and 49%[13] were demonstrated in other studies. Opposite positive predictive value results at 88%[11] and 40%[13] were reported. However, a good diagnostic accuracy of the test (72%) was recorded.[12] The inconsistent data in these studies may result from many factors such as differences in the study design and approach, group selection, distribution pattern of rotator cuff tear, degree of the lesion and patient presentation at the time of the study,[11] and the reference standard.[12] More importantly, the complexity and multiplicity of the subacromial anatomic structures and their various pathologies would have a prominent role in the validation data discrepancy of the Neer test, because the pathologic lesions in the subacromial region may exhibit similar clinical symptoms.[12] The intimate relationship between multiple anatomic structures of different nature located in a tight subacromial complex may explain the presentation similarity of patients having different shoulder disorders. For example, some cases of adhesive capsulitis, calcific tendinitis, myofascial pain syndrome, and glenohumeral osteoarthritis may present as subacromial impingement syndrome[12] and therefore they may demonstrate a positive test. Also, the combined results of Calis et al[12] and MacDonald et al[13] confirm this notion as they reflect the interplay of multiple anatomic structures in the subacromial region. For the same reason, similar test sensitivity was recorded at 75% in subacromial bursitis vs 83% in rotator cuff pathology in MacDonalds data.[13] Together, all the clinical data would strongly support the high sensitivity and poor specificity of the test, and consequently the difficult differential diagnosis. This would limit the validity of the Neer test as a peculiar indicator of rotator cuff or long tendon of biceps brachii pathology. However, it could be a useful tool of screening for rotator cuff lesions rather than diagnosis.

Although the Neer test is one of the frequently used clinical tests by clinicians for impingement syndrome diagnosis,[14] the high sensitivity and low specificity of the test would suggest the reliability of a negative test in ruling out a rotator cuff lesion rather than confirming the diagnosis. Therefore, a positive Neer test should be combined with an additional clinical test such as the drop-arm test to confirm the diagnosis of a supraspinatus lesion.

Hawkins-Kennedy test

An alternative to the Neer test for assessing involvement of supraspinatus or long head of biceps brachii muscle is the

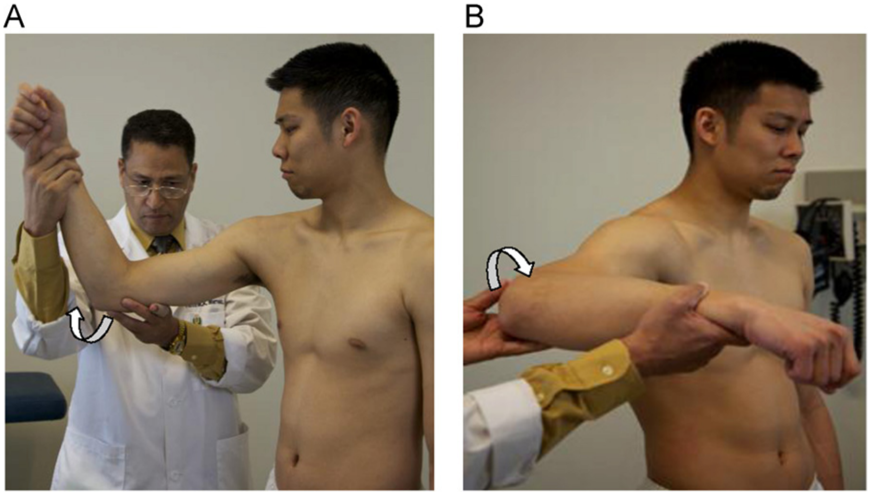

Figure 2 (A) The Hawkins-Kennedy test. (B) The Hawkins-Kennedy test.

Hawkins-Kennedy test. In their original study,[10] authors assumed that their test was less reliable than the Neer test. In the Hawkins-Kennedy test, the patient stands in the anatomic position. The examiner stands lateral to and facing the involved side. With one hand grasping the elbow and the other hand grasping the wrist, both the elbow and the shoulder are flexed simultaneously to 90°. Once positioned properly, the examiner internally rotates the patient's humerus in the glenohumeral joint. A positive test is indicated when the patient experiences pain especially toward the end of the motion. A positive response may be a sign of rotator cuff pathology of supraspinatus or long head of biceps brachii tendons (Figure 2A and B).

Rationale

The passive positioning of the glenohumeral and elbow joints in 90° flexion places shoulder flexors (anterior fibers of deltoid and long head of biceps brachii muscles) and supraspinatus muscles in a relaxed position. In this position, the tendons of long head of biceps brachii and supraspinatus lie in close contact with the anteroinferior surfaces of acromion and coracoacromial ligament.[9] When the internal rotation motion occurs in the glenohumeral joint, the greater tuberosity of the humerus comes in close contact with the acromion undersurface impinging the 2 tendons in succession.[10] Documented by ultrasound dynamic visualization, the greater tuberosity causes bulging of the coracoacromial ligament, which is a key impinging structure in subacromial impingement syndrome.[15] Pain elicited during internal rotation movement may indicate inflammation or a tear of either supraspinatus or long head of biceps tendons, although supraspinatus lesions are surgically confirmed as the most frequent in this region.[16]

Validation of the Hawkins-Kennedy test showed high sensitivity (91% and 92%), however, poor specificity (25% and 44%).[12,13] In other studies, moderate sensitivity at 78.3% and 69% and moderate specificity at 50% and 48% were documented.[11,17] The diagnostic value of the test in classifying patients accurately was found to be 75%.[12] These results are comparable to the Neer test validity as the scientific rationale and involved anatomic structures of both tests are similar. Based on these results, clinicians may use the Hawkins-Kennedy test or the Neer test interchangeably. Combining the 2 tests will not increase predictive diagnosis but either one may produce similar performance characteristics.[13] Thus, a negative Hawkins-Kennedy test could rule out a rotator cuff lesion and a positive test could be followed by the drop-arm test to confirm a rotator cuff lesion.

The Jobe test (Empty-Can Test)

The Jobe test usually is used to confirm a rotator cuff tear in supraspinatus tendon as demonstrated by inability to resist the examiner's force. This test was originally described by Jobe and Moynes[18] and Jobe and Jobe[19] as the

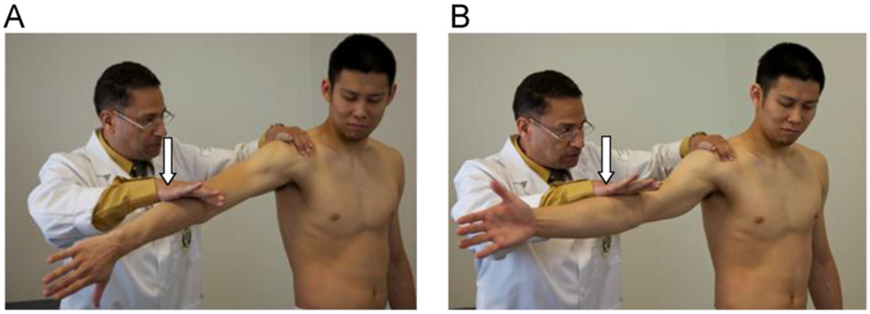

Figure 3 (A) The Jobe (Empty Beer Can) test, thumb up. (B) The Jobe (Empty Beer Can) test, thumb down.

"supraspinatus test". It is also known as the "empty-can test". Later, Kelly et al[20] suggested an alternative less provocative method, the "full-can test" Figure 3A and B).

As originally described by Jobe in the first part, empty-can component, the patient is seated. The examiner stands behind the patient and instructs the patient to horizontally flex the arm at the shoulder to 90°, abduct the limb to 30° along the scapular plane, and internally rotate so the thumb points downwards (empty-can position). The examiner asks the patient to resist the downward movement and then applies a quick downward pressure on the arm. In the second part of the test, full-can component, the examiner asks the patient to externally rotate the 90° abducted limb so that the thumb points upwards (full-can position) without horizontal flexion of the glenohumeral joint. Again, the examiner instructs the patient to resist and then applies a downward pressure on the arm(s). Both test maneuvers should be applied to both limbs simultaneously to establish a basis for comparison. In both maneuvers a positive test is indicated by inability of the patient to resist the examiner's downward movements in the involved arm, compared with the intact side. A positive test is interpreted as strongly indicative of a rotator cuff tear in supraspinatus tendon of the involved side.

Rationale

Shoulder joint positioning in the empty-can test places the middle fibers of deltoid and subscapularis muscles in full active contraction to maintain arm abduction. This position also limits or neutralizes the function of the other rotator cuff muscles.[18] Prior to performing the initial maneuver, it is recommended to assess deltoid muscle function with a similar quick resistance application with the arm at 90° abduction and neutral rotation.[19] With confirmation of an intact deltoid muscle, a weak or painful response to resistance of the arm in rotation may suggest supraspinatus disruption. The empty-can maneuver is provocative of pain as the internal rotation of the arm impinges supraspinatus tendon between the greater tuberosity and coracoacromial arch.[21] In the full-can maneuver, however, the humerus is in 45° external rotation, which disengages the greater tuberosity, and hence supraspinatus tendon, from the undersurface of the acromion. This makes the full-can test less provocative than the empty-can test.[20]

Many studies evaluated the effectiveness of the Jobe test in diagnosing rotator cuff lesions. When weakness was used as the diagnostic criterion, good sensitivity (68°-95°) and specificity (68%-90%) were shown.[22-25] However, 1 study showed low sensitivity (43%) and good specificity (80%) for the same diagnostic criterion.[11] When pain exacerbation was the diagnostic criterion of the test, less satisfactory results were achieved. Together, weakness and pain as diagnostic criteria slightly lowered sensitivity (77%-82%) and specificity (50%-70%).[23,25] When the reference standard was tendon damage with or without tear, sensitivity was usually greater than specificity.[26-28] This may partially explain the weak correlation between the degree of tendon tear and a positive Jobe test.[28,29] In contrast, good diagnostic accuracy (70%-85%) was demonstrated.[22,23]

The discrepancy of the Jobe test validity results between authors may attribute to activation of other muscles of the shoulder complex to the same level as supraspinatus activation.[21] Infraspinatus, upper subscapularis, trapezius, and serratus anterior are among the activated muscles in the Jobe test as demonstrated by EMG study.[21]

Based on the sensitivity and specificity of the 2-part Jobe test, a clinician can rely on the test to both screen for and confirm a rotator cuff lesion when weakness is used as the diagnostic criterion. Nevertheless, proper performance of the Jobe test requires adequate experience and deep understanding of underlying functional anatomy of the shoulder complex. For the clinician who lacks sufficient caseloads to maintain expertise in this test, combining the Jobe test with the Neer or the Hawkins-Kennedy test, can serve as a confirmatory test for rotator cuff lesion provided that deltoid muscle is intact.

Painful arc test

The painful arc test requires active movement by the patient and suggests a provisional diagnosis particularly for a rotator cuff lesion. The painful arc test was first described by Neer[30] when he suggested patients with rotator cuff syndrome would demonstrate pain with arm elevation between 70° and 120° (Figure 4).

To perform the test, the patient is in a standing or seated position with arms resting at the side. The examiner stands facing the patient. The examiner then instructs the patient to slowly abduct both limbs simultaneously from 0° to 180° overhead. A positive sign is indicated by pain between 60° and 120° arm abduction, or between 170° and 180° arm elevation. Pain at 60°-120° suggests subacromial bursitis or rotator cuff (supraspinatus) tendonitis or rupture. In case of rotator cuff rupture or complete tear, the patient may lose the ability to abduct the involved limb beyond 120°. Otherwise, pain at 170°-180° suggests acromioclavicular joint injury or pathology.

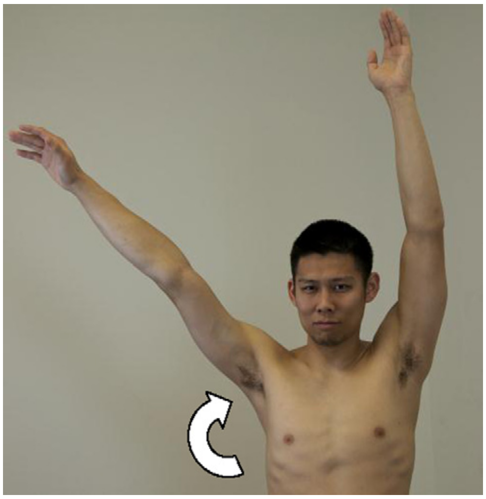

Figure 4 The painful arc test.

Rationale

The painful arc test rationale supports the distinctive role of supraspinatus muscle during the synergistic muscle action of the arm abductors. Although the primary action of supraspinatus is initiating arm abduction, there is almost always an overlap of muscle action throughout the range of motion.[31] Assuming an overlap of action between the middle fibers of deltoid and supraspinatus muscles during the first and second phases of arm abduction, supraspinatus dysfunction would not completely prevent the initiation of abduction, but would rather result in an observable decrease of the synergistic effect associated with shoulder pain, as the arm moves into the second phase of arm abduction (60°-120°). As the synergistic effect is decreasing in the second phase of arm abduction, early scapular rhythm initiates to complete the second phase of arm abduction. The scapula pivots laterally around its anteroposterior axis before full glenohumeral abduction takes place. This pivoting gives the characteristic sign of raising the involved shoulder[32] as a result of upward orientation of the glenoid fossa.

The third phase of arm abduction occurs as a result of scapular rhythm caused by the combined effect of trapezius and serratus anterior muscle contractions. The acromioclavicular joint is strained because of lateral rotation of the scapula around its anteroposterior axis, associated with inward compression forces generated by the head of the humerus. In case of acromioclavicular pathology, pain localizes at the acromioclavicular joint limiting full-arm elevation at the last 10° of arm abduction (170°-180°). Well-designed studies to confirm this hypothesis could not be located.

There is a marked discrepancy between studies in defining the diagnostic value of the painful arc test when validated against sensitivity and specificity. The sensitivity showed an average of 31%[14] vs 97%,[26] 80%,[33] and 72%.[11] Conversely, the specificity showed 80%[14] vs 10% [40] and 63%.[11] The variability in the authors' results may reflect significant differences in the validation criteria of the test. Other than the technical and sampling bias, which is out of the scope of this study, the variable sensitivity and specificity results may also be attributed to anatomic and pathologic reasons involved in supraspinatus tendon disorders. As an example, subacromial impingement is only one of many causative factors of tendon pathology.[34] This potentially means that many underlying anatomic structures and associated pathology may be involved in this test.

Despite its simplicity, the painful arc test is hard to interpret clinically as it embraces multiple intervening mechanisms that involve concentric contraction of shoulder muscle adductors. Nevertheless, the painful arc test is very popular among orthopedic surgeons for its clinical diagnostic value in ruling in or ruling out rotator cuff tears.[33] This is a clear example of the potential disagreement between the test validation and clinical implications based on anatomic and basic science reasoning. Practitioners without primary caseloads involving potential rotator cuff tears should consider using the painful arc test as a complementary or adjunct to other tests.

Drop-arm (Codman) test

Codman[35] described the drop-arm test for diagnosing complete rupture of supraspinatus tendon. (Note: The Codman drop-arm test is not the same as the similarly named "drop sign" described by Hertel[27] for infraspinatus muscle and tendon assessment) (Figure 5A and B).

To perform the Codman drop-arm test, the patient is preferably in the standing position with the examiner standing lateral and behind the involved limb. The examiner passively abducts the patient's arm to 90°. Then, the examiner releases his hand and instructs the patient to hold the arm horizontally and then slowly lower the arm from the fully abducted position. A sudden drop to the side or jump of the arm at any point may indicate a positive test and a possible rupture of supraspinatus tendon.

Rationale

The drop-arm test appears as an inverse maneuver of the painful arc test; however, the concept and biomechanical basis of the 2 tests are different. The drop-arm test elicits an active eccentric contraction of the arm abductors vs concentric contraction of the same muscle groups in the painful arc test. Eccentric contractions assist in maintaining smoothness of joint motions[36]; all shoulder joint abductors undergo eccentric contraction on performing controlled adduction of the arm. A deficit of strength or integrity of any

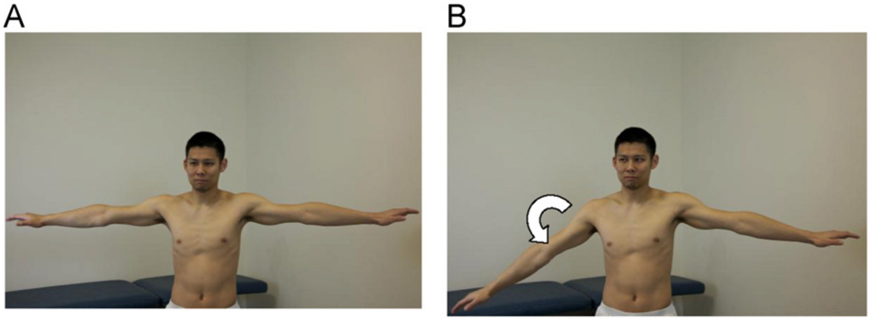

Figure 5 (A) The drop-arm (Codman) test. (B) The drop-arm (Codman) test.

of the arm abductors due to trauma or pathologic lesions would hypothetically cause a sudden drop of the arm or interruption of the smoothness of the arm's arc of motion. As eccentric contraction force exceeds the concentric contraction force of the same muscle by about 10%,[36] it is assumed that the slight deficit in the muscle power can be observed during the clinical test.

Sudden drop of the arm associated with pain during the drop-arm test may strongly suggest subacromial impingement syndrome.[37] Impingement syndrome may occur with a rotator cuff strain or injury or any other shoulder abductor injury such as deltoid insufficiency, subacromial bursitis, tendinitis, or impingement of the shoulder joint.[10]

The drop-arm test was found to have very low sensitivity (average 16%) and high specificity (average 92.5%).[11,12,38] The test's low sensitivity may indicate weakness of the test in ruling out a rotator cuff injury. However, the test provides significant success in diagnosing rotator cuff injury with high accuracy because of its high specificity. The low sensitivity is explained by the involvement of multiple anatomic structures around the shoulder so the functional overlap masks the pain sensation and compensates for the weakness responsible for the arm drop. The role of rotator cuff muscles, in particular, as a fine controller[5] in arm adduction explains the high specificity of the test. The consistency of the test validation results and the hypothesized anatomic analysis makes the drop-arm test a good match to complement or improve the painful arc test results in diagnosing supraspinatus lesion, as previously suggested.[32] The drop-arm test combined with another specific test for a rotator cuff lesion, such as the Hawkins-Kennedy test, improves diagnostic accuracy particularly for full-thickness supraspinatus tear. Also, as rotator cuff muscles are the most commonly injured muscles in the shoulder complex in elderly people[16]; use of the drop-arm test as an initial screening tool in older patients with shoulder dysfunction may be a good indicator of a rotator cuff lesion.

Conclusion

Supraspinatus muscle is the most frequently injured muscle of the rotator cuff.[7] Multiple clinical tests have been developed to evaluate its function; however, individually, the discussed tests are hardly discriminatory diagnostic tools. To explore their diagnostic utility, clinical tests may be evaluated quantitatively via statistical test or surgical validation or, qualitatively via in-depth understanding and reasoning of the underlying basic science in cadaveric or in vivo studies. Test validation studies demonstrate inconsistent results due partly to variability of validation parameters and the selected methodology. However, many clinical tests of the shoulder complex demonstrate poor diagnostic value despite frequent clinical use and popularity as diagnostic tools. Therefore, caution is required in the interpretation of test validation results in clinical studies.

Enhanced understanding of the underlying basic science of clinical tests of the shoulder complex and the results of sensitivity and specificity studies should affect the clinician's selection of an appropriate test, and therefore shape the clinical outcome of ruling in or ruling out a rotator cuff lesion, or offering flexibility in the workup. However, validation statistics of supraspinatus testing should not override the clinical judgment of the practitioner based on appreciation and reasoning of the underlying basic science. Also, reasoning of the underlying basic science concepts should be the guide of a clinician to either use a test independently or further supplement it with a complementary test toward confirming the diagnosis on a case-by-case basis. As a general rule, combined tests, such as the Neer test with the drop-arm test, demonstrate enhanced diagnostic accuracy.

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