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SYSTEMATIC REVIEW

A PROPOSED EVIDENCE-BASED SHOULDER SPECIAL TESTING EXAMINATION ALGORITHM: CLINICAL UTILITY BASED ON A SYSTEMATIC REVIEW OF THE LITERATURE

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ABSTRACT

Objectives: Attaining the highest possible level of diagnostic statistical probability assists the practitioner in making an optimal differential diagnosis between or among pathological conditions. The purpose of this manuscript is to accomplish two things. The first is to identify orthopedic shoulder physical examination special tests with the best clinical utility statistics to ease the diagnostic process through usage of an examination algorithm. The second is to expedite the diagnostic process by guiding the practitioner to select only the special tests that are necessary based on pattern recognition of common pathological conditions.

Methods: Systematic review of the literature identified the statistical clinical utility of common shoulder special tests used in physical examination, either singularly or in clusters. Quality assessment and statistical parameters were designed for inclusion criteria to determine diagnostic data for special test selection for the proposed algorithm.

Results: In the proposed shoulder examination algorithm, 15 of 26 special tests achieved the proposed statistical diagnostic threshold parameters for clinical utility. Achievement of proposed statistical diagnostic threshold parameters was accomplished for 6 pathological shoulder conditions; while 3 pathological shoulder conditions did not achieve these criteria.

Discussion: Large, randomized controlled trials that include patient history and all facets of the physical examination are lacking in the literature. Should diagnostic physical examination testing become more accurate, it is very possible that improved research can be accomplished, in order to establish clinical practice guidelines to help guide examination and treatment, patient management, and improve patient outcomes.

Keywords: Differential diagnosis, evidence-based practice, orthopedic special tests, shoulder.

Level of evidence: 1A.

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INTRODUCTION

Subjective data, patient history, and physical objective data are of paramount importance in the clinical diagnostic process. Differentially diagnosing between or among various pathological conditions is of great importance in physical medicine for many reasons. Accuracy in diagnosis guides the practitioner toward proper interventions that comprise the plan of care. Costly diagnostic testing may be less necessary if an accurate diagnosis through physical examination by physical therapists or physicians is determined. Ruling out certain diagnoses may also make referral to other providers markedly less necessary by deeming a patient most appropriate for physical therapy treatment versus other interventions.

Orthopedic special tests aim to make the diagnostic process more precise by implicating specific tissue structures that are dysfunctional, pathological, or lack structural integrity. Uses of special tests include confirming a tentative diagnosis, assisting in the differential diagnosis process, distinguishing between or among various potentially pathological tissues that may be symptomatic, and making sense of atypical objective and subjective patient signs and symptoms. Clinical diagnosis then leads the practitioner to establish a prognosis and select appropriate interventions, ultimately and ideally leading the patient to an optimal outcome.

Special testing is traditionally performed after taking a full subjective examination and a full objective examination that includes but is not limited to patient history and mechanism of injury, clinical observation, bony and soft tissue palpation, assessment of active and passive physiological movements, assessment of passive arthokinematic/accessory joint mobility, neurological assessment, manual muscle testing, and functional assessments. The purpose of this systematic review is to identify orthopedic shoulder physical examination special tests with the best clinical utility statistics to facilitate the diagnostic process through usage of an examination algorithm. An additional purpose is to expedite the diagnostic process by guiding the practitioner to select special tests that are only necessary based on pattern recognition of common pathological conditions.

METHODS

Systematic Literature Review: Quality and Statistical Parameters

The probability that an individual either does or does not possess a pathological condition ultimately allows a practitioner to designate a specific diagnosis. The use of pre-test and post-test probabilities, as compared with merely reporting sensitivity and specificity data, allow a more explicit and rational interpretation of the statistical utility of diagnostic tests.[1] Post-test probabilities, along with the pre-test probabilities and likelihood ratios from which the post-test probabilities are derived, are in my opinion the statistics most relevant to patient management. Reporting this data is important for a number of reasons: 1) the coupled impact on decision making for test performance on the patient's pre-existing disposition for the condition is known; 2) further research priorities are highlighted; 3) revised post-test probabilities can be calculated if pre-test probabilities change; 4) revised post-test probabilities can change if better performing diagnostic tests become available; 5) exposure to pre-test and post-test probabilities help clinicians gain confidence if their application.[1]

Pattern recognition of findings deemed typical for a specific pathology help determine a working diagnostic hypothesis. To allow a value given for this pattern recognition, a pre-test probability statistic is necessary. Pre-test probability is the likelihood that a patient exhibits a specific pathology before the clinical examination is performed. Prevalence rates are often used as an indication of pre-test probability. In circumstances where prevalence rates are unknown, pre-test probability is an estimate based on a combination of a patient's history and a clinician's experience as is relates to pattern recognition.[1] It is estimated by the author that a specific shoulder pathological condition may be correctly ascertained 50% of the time after subjective and objective examination of a patient without the use of special tests. Pre-test probability is therefore estimated at 50% for data calculated in this study. Published specificity and sensitivity values were used to calculate positive and negative likelihood ratios if they were not already given. Post-test probabilities were calculated using these published and/or calculated values with a pre-test probability set at 50%. Table 1 illustrates

Table 1. *Definitions and Formulas used to Calculate Clinical Utility Statistics.*	
Definitions	**Formulas**
Pre-Test Probability	Prevalence (estimated proportion of the population with the disorder); set at 50% (.5).
Pre-Test Odds	Prevalence/(1-Prevalence)
Specificity	True Negatives/(True Negatives+False Positives)
Sensitivity	True Positives/(True Positives+False Negatives)
Positive Likelihood Ratio	Sensitivity/(1-Specificity)
Negative Likelihood Ratio	(1-Sensitivity)/Specificity
Post-Test Odds	Pre-Test Odds x Likelihood Ratio
Post-Test Probability	Post-Test Odds/(Post-Test Odds+1)

the definitions and formulas used for calculations contained in this manuscript.

Special tests with the best current evidence-based statistical utility profile were chosen for inclusion in the proposed examination algorithm. Determining whether a specific special test or Test Item Cluster (TIC) had the statistical utility necessary to be included in the examination algorithm included two requirements. The first requirement was that in order to rule in the condition, 80% or greater post-test probability for a specific pathological shoulder condition was required. The second requirement was that in order to rule out a condition 20% or less post-test probability that the patient will exhibit a specific pathological shoulder condition when the test does not indicate such was required. If a specific special test or TIC met both requirements, the definition of successful diagnostic threshold was met. Procedures for in-depth description of how to perform each special test are outside the scope of this study, and this information is readily available by utilizing the references accompanying this study.

Comprehensive retrieval of as many articles as possible on the statistical utility of shoulder special tests was attempted by employing a search strategy previously reported by Haynes and Wilcynski.[2] Though this strategy was reported for use with MEDLINE, it was used by the author to retrieve additional articles from the CINAHL, PubMed, and SPORTDiscus databases if they had not already been retrieved. Databases were searched for papers published between January 1975 and June 2013.

After article retrieval, quality assessment of those articles containing special test data was performed. Internal and external validity were evaluated by the author using the Quality Assessment of Diagnostic Accuracy Studies (QUADAS) tool. The QUADAS scoring system for quality assessment includes 14 questions regarding methodology of a chosen article.[4] Scores indicating a high-quality diagnostic study of statistical utility have been previously graded at 7 or higher by other authors in the review of other diagnostic testing statistics.[5,6] After quality assessment was completed, those articles that included adequate statistical data that met the diagnostic threshold as described were included in the proposed examination algorithm. In the event that a singular special test had two or more articles that had statistical utility data reports, the inferior statistical utility data set was used with regards to both quality and clinical utility statistics.

Statistical data quality, accuracy, and precision were all necessary for inclusion of the selected special tests. Due to the fact that many special tests had numerous data citations with wide variance, both accuracy and precision were necessary for appropriate data selection for inclusion in the algorithm. For this reason, the most inferior data set for each special test was used in the selection process. Wide variance in data for a number of special tests and a wide range in the number of reported data sets per each special test made this a necessity. Other means for reporting statistical data such as the mean, median, mode, range, or use of the best data set for each test was deemed inappropriately cautionary for clinical utility.

RESULTS

I. Development of the Proposed Evidence-Based Shoulder Special Testing Examination Algorithm

Initial Hypothesis Based on Subjective and Objective Data

Indication for utility of any algorithm-based special testing begins with a quality subjective and objective examination. This provides the practitioner with a

working hypothesis as to the nature and or cause of the pathology. Pattern recognition of common signs and symptoms may be indicative of the potential nature of a patient's shoulder condition.[3,7]

Patient reports of anterior/lateral pain, pain with overhead motion, demonstration of a painful arc with active shoulder elevation, and night pain may be indicative of rotator cuff tendinopathy and/or subacromial impingement syndrome.[3,7]

Complaints of anterior/lateral pain, compensatory shoulder shrugging with overhead motion, gross functional disabilities, constant achiness in the shoulder, night pain, pain that wakes that patient during sleep, and patient age of 40 or greater may be indicative of a rotator cuff tear.[3,7]

Reports of anterior pain, apprehension and/or pain in positions of abduction and external rotation, a history of anterior/inferior trauma, recurrent or volitional anterior/inferior subluxations and/or dislocations, joint clicking/clunking, complaints of joint locking, and a history of "dead arm syndrome" may be indicative of anterior capsulolabral instability, anterior labral lesions, or Bankart lesions.[3,7]

Deep posterior pain, apprehension and/or pain in positions of horizontal adduction, apprehension or pain during activities that involve pushing (especially coupled with horizontal adduction), apprehension or pain during closed kinetic chain (CKC) positions, a history of posterior/inferior trauma, recurrent or volitional posterior/inferior subluxations and/or dislocations, and complaints of joint clicking/clunking may be indicative of posterior capsulolabral instability or labral lesions.[3,7]

Patients with SLAP lesions may have deep shoulder pain, complaints of clicking/clunking, complaints of joint locking, pain with activities that require eccentric deceleration of the upper extremity (such as throwing or swinging), and pain with muscular loading of the biceps (especially during shoulder flexion and arm supination).[3,7]

Very specific posterior/superior pain during shoulder abduction and external rotation as well as possible pain during activities that require eccentric deceleration of the upper extremity (such as throwing or swinging an object) may be indicative of an articular-sided internal impingement syndrome of the rotator cuff.[3,7]

Primary complaints of anterior pain, painful palpation to the proximal aspect of the long head of the biceps (LHB), pain with activities that require eccentric deceleration of the upper extremity (such as throwing or swinging an object), and pain with muscular loading of the biceps (especially during shoulder flexion and arm supination) may be indicative of LHB tendinopathy.[3,7]

Patient's with an acromioclavicular (AC) joint lesions may report superior joint pain, pain with end-range elevation activities, pain with horizontal adduction activities, painful palpation to the AC joint, a notable AC joint "step-off" on observation, and an injurious mechanism that involves a fall on the shoulder.[3,7]

Designation into Pathological Sub-Categories

To begin testing a working hypothesis based on a clinician's subjective intake, dividing patients with varying presentations into pathological sub-categories is indicated to be performed on all patients. Musculoskeletal shoulder pathology can be subdivided into three major categories: intra-articular pathology, extra-articular pathology, and rotator cuff pathology. One screening test appears to be extremely successful to rule in or rule out both intra-articular pathology and rotator cuff pathology[8]. The data for the proposed screening test is presented in Table 2.

The operational definition of rotator cuff pathology is as follows: Findings that include a thickened or inflamed subacromial bursa, erosions on the CA ligament and undersurface of the acromion, and bursal side partial or full thickness rotator cuff tears.[8]

The operational definition of intra-articular pathology is as follows: Findings that included glenoid erosion or labral tears, middle GH ligament tearing, articular-sided rotator cuff partial tears, posterior labral lesions, and SLAP lesions[8].

The post-test probability that the patient will exhibit either intra-articular pathology or rotator cuff pathology is 91.7% when the internal rotation resisted strength test (IRRST) implicates such. The post-test probability that the patient will exhibit either intra-articular pathology or rotator cuff pathology when the test does not indicate such is 6.1%. Inconclusive testing (nor-

Table 2. *Statistical Data for Selected Screening Test.*

Test	Applicable Findings	Sp*	Sn†	+LR‡	-LR§	+Post-Test Probability	-Post-Test Probability
Internal Rotation Resisted Strength Test[8]	In 90° abduction and 80° external rotation, if internal rotation strength<< external rotation strength (IR MMT<<ER MMT) the test is positive for intra-articular pathology. If internal rotation strength>>external rotation strength (ER MMT>>IR MMT) the test is positive for rotator cuff pathology.	.96	.86	22.0	.13	91.7%	6.1%

*Specificity
†Sensitivity
‡Positive likelihood ratio
§Negative likelihood ratio

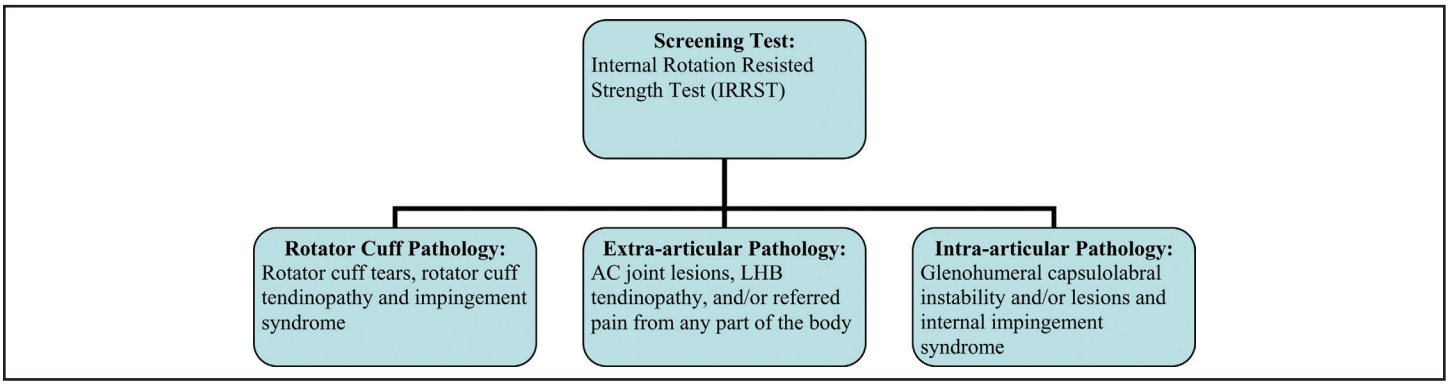

Figure 1. *The Internal Rotation Resisted Strength Test (IRRST) allows the practitioner to categorize a shoulder condition into one of three categories: rotator cuff pathology, extra-articular pathology, or intra-articular pathology.*

mative values for IR and ER manual muscle testing), therefore, can be used to rule out both intra-articular pathology and rotator cuff pathology. One can deduce that an extra-articular pathology or pain referred from a different area of the body may be present with an inconclusive test. The QUADAS score was 7 for the article in which statistical data was attained and calculated for these post-test probability statistics.[8]

The examiner should then be able to place the patient into an appropriate diagnostic test sub-category with a high level of confidence based upon this screening test (Figure 1).

ROTATOR CUFF (RTC) PATHOLOGY

A. Rotator Cuff Tendinopathy/Impingement Syndrome

Testing for this pathology is indicated with a positive IRRST (IR MMT > > ER MMT) and other appropriate signs and symptoms suggested by a recognizable pattern formed in the initial hypothesis for rotator cuff tendinopathy/impingement syndrome. The data for the proposed RTC tendinopathy/impingement syndrome tests are presented in Table 3.

The Test Item Cluster (TIC) of the Hawkins-Kennedy test, the infraspinatus muscle test, and the painful arc sign together have the best statistical utility data that met the proposed post-test probability parameters. Post-Test probability for the TIC of the three above tests is 95.5% if all 3 are positive, and 91.0% if 2 of 3 are positive as reported by Park and colleagues[9]. The post-test probability that the patient will exhibit rotator cuff tendinopathy and/or impingement syndrome when the TIC doesn't indicate such is unknown, as the –LR data was not reported[9]. The QUADAS score is 10 for the article in which statistical data was attained and calculated for these post-test probability statistics.[9]

Table 3. *Statistical Data for Selected Rotator Cuff Pathology Special Tests.*

Test	Applicable Findings	Sp*	Sn†	+LR‡	-LR§	+Post-Test Probability	-Post-Test Probability
Test Item Cluster for Rotator Cuff Impingement and/or Tendinopathy[9]	Hawkins-Kennedy Test, Infraspinatus Muscle Test, and Painful Arc Sign are all positive.	NR	NR	10.56	NR	95.5%	NR
Test Item Cluster for Rotator Cuff Impingement and/or Tendinopathy[9]	Two of three tests are positive: Hawkins-Kennedy Test, Infraspinatus Muscle Test, and Painful Arc Sign.	NR	NR	5.03	NR	91.0%	NR
External Rotation Lag Sign (ERLS) for Supraspinatus and/or Infraspinatus Tear[16,17]	Shoulder is held in 20^0 of abduction in the scapular plane, nearly full external rotation, and 90^0 of elbow flexion. Inability to keep the shoulder in near maximal external rotation indicates a positive test.	.98	.69-.98	15.5-34.50	.2-.32	88.8%	13.8%
Dropping Sign @ 90^0 abduction and 45^0 external rotation for Infraspinatus Tear[17]	Inability to hold shoulder in external rotation in described position.	1.00	1.00	0.00	0.00	NA	NA
Hornblower's Sign for Teres Minor Tear[17]	Inability to externally rotate to "Hornblower" position.	.93	1.00	14.29	0.00	87.7%	NA
Internal Rotations Lag Sign (IRLS) for Subscapularis Tear[16]	Patient's hand is placed behind the back with 90^0 of elbow flexion. Examiner extends shoulder 20^0, forcing the hand off the back. Inability to hold this position is a positive test.	.96	.97	24.3	.03	92.4%	1.48%

*Specificity
†Sensitivity
‡Positive likelihood ratio
§Negative likelihood ratio
Post-test probabilities for the RTC impingement/Tendinopathy TIC were reported by Park et al[9] under parameters in their study. They were not calculated with the given +LR statistics above.

Special tests with reported data for rotator cuff tendinopathy/impingement syndrome that fail to consistently meet the diagnostic threshold for use in this study included the Hawkins-Kennedy test,[9,10,11,12,13,14] the Neer test,[10,11,12,13,14,15] the Yocum test,[12,14] the horizontal adduction test,[9,11] the painful arc sign,[9,11] the empty can test,[9,11,14] the drop arm test,[8,9] the Speed test,[9,10,11] the Yergason test,[8,9] the Pattes test,[14] the Gerber lift-off test,[14] the Jobe relocation test,[14] and the Gilcrest palm-up test.[14]

B. Rotator Cuff Tears

Testing for this pathology is indicated with a positive IRRST (IR MMT>>ER MMT) and other appropriate signs and symptoms suggested by a recognizable pattern formed in the initial hypothesis for a rotator cuff tear. The data for the proposed rotator cuff integrity tests are presented in Table 3.

The external rotation lag sign (ERLS)[16,17] the dropping sign,[17] the hornblower's sign,[17] and the internal rotation lag sign (IRLS)[16] have the best statistical utility data that met the proposed post-test probability parameters. The post-test probabilities that the patient will exhibit rotator cuff tears are 88.8% (at minimum) for the ERLS, approximately 100% for the dropping sign, 87.7% for the hornblower's Sign, and 92.4% for the

IRLS. The post-test probabilities that the patient will exhibit rotator cuff tears are 13.8% (at maximum) for the ERLS, approximately 0.0% for the dropping sign, approximately 0.0% for the hornblower's Sign, and 1.48% for the IRLS when the test does not indicate such. The QUADAS scores were 7 for both articles in which statistical data was attained and calculated for these post-test probability statistics.[16,17]

Special tests with reported data for rotator cuff tears that fail to consistently meet the diagnostic threshold for use in this study included the empty can test,[9,12.16,19,20,21] the full can test,[21] the Neer test,[9,13] the Hawkins-Kennedy test,[9,13] the Rent test,[22,23] the Gilcrest palm-up test,[9,12,18] drop sign in 90 degrees abduction in the scapular plane and 90 degrees of external rotation,[9,16,24] the lift-off test,[12,16,25,26,27] the belly-off test,[27] the Napolean test,[25,27] the bear-hug test,[25] the supine impingement sign,[21] the infraspinatus muscle test,[9] the painful arc sign,[9,21] the cross-body adduction test,[9] the Gerber lift-off test,[26] manual muscle testing of the supraspinatus combined with palpation,[22] manual muscle testing of the infraspinatus combined with palpation,[22] passive elevation of less than 170 degrees,[21] passive external rotation of less than 70 degrees,[21] supraspinatus atrophy,[21] and infraspinatus atrophy.[21]

INTRA-ARTICULAR PATHOLOGY

A. Anterior/Anterior-Inferior Glenohumeral Instability

Testing for this pathology is indicated with a positive IRRST (IR MMT << ER MMT) and other appropriate signs and symptoms suggested by a recognizable pattern formed in the initial hypothesis for anterior glenohumeral instability. The data for the proposed anterior/anterior-inferior glenohumeral instability tests are presented in Table 4.

The apprehension test[28,29] and the anterior release test (surprise test)[29,30] have the best statistical utility data that met the proposed post-test probability parameters. Post-test probabilities for the above tests are respectively 91.0% and 80.7% at minimum. The post-test probabilities that the patient will exhibit anterior/anterior-inferior glenohumeral instability when the above tests are negative are respectively 19.0% and 15.6% at maximum. QUADAS scores are respectively 10, 11, and 9 for the articles in which statistical data was attained and calculated for these post-test probability statistics.[28,29,30]

Special tests with reported data for anterior/anterior-inferior glenohumeral instability that fail to consistently meet the diagnostic threshold for use in this study included the sulcus sign,[31,32,33,34] the Feagin test,[34] the apprehension test (for a labral tear or for pain as opposed to apprehension),[33,35] the Jobe relocation test,[29,33,35,36,] the anterior slide test,[37,38] the anterior load and shift test.[31,33]

B. Bankart Lesion and/or Anterior Labral Tear

Testing for this pathology is indicated with a positive IRRST (IR MMT << ER MMT) and other appropriate signs and symptoms suggested by a recognizable pattern formed in the initial hypothesis for a Bankart lesion and/or an anterior labral tear. The data for the proposed Bankart lesion/anterior labral tear tests are presented in Table 4.

The TIC that includes that crank test, the apprehension test, the Jobe relocation test, the anterior load and shift test, and the sulcus sign test have the best statistical utility closest to the proposed post-test probability parameters.[33] Post-test probability for the TIC is 75.0%. The post-test probability that a patient will exhibit a Bankart lesion (and/or an anterior labral tear) when the TIC does not indicate so is 7.0%. Because the proposed post-test parameters have not been met, diagnostic threshold at this time is proposed to be reproduction of the patient's primary complaint in conjunction with a positive Test Item Cluster as described in spite of the lack of statistical evidence. The QUADAS score is 11 for the article in which statistical data was attained and calculated for these post-test probability statistics.[33]

Special tests that have also reported data for a Bankart lesion (and/or anterior labral tear) that fail to consistently meet the diagnostic threshold but have inferior data sets to the TIC as described above include the Clunk tests (clunk test and clunk test II)[3,34] and the Crank test.[33,34,35,39,40,41,42,43]

C. Posterior/Posterior-Inferior Glenohumeral Capsulolabral Instability and Labral Lesions

Testing for this pathology is indicated with a positive IRRST (IR MMT << ER MMT) and other appropriate signs and symptoms suggested by a recognizable pattern formed in the initial hypothesis for posterior

Table 4. *Statistical Data for Selected Intra-Articular Pathology Special Tests.*

Test	Applicable Findings	Sp*	Sn†	+LR‡	-LR§	+Post-Test Probability	-Post-Test Probability
Apprehension Test for Anterior or Anterior/Inferior Instability[28,29]	Apprehension to test position of 90^0 abduction, 90^0 of elbow flexion, and maximal external rotation.	.96-.99	.53-.72	20.2-53	.29-.47	91.0%-96.4%	12.7%-19.0%
Anterior Release Test (also known as Surprise Test) for Anterior or Anterior/Inferior Instability[29,30]	Apprehension or pain when posterior relocation is removed in test position of 90^0 abduction, 90^0 of elbow flexion, and maximal external rotation.	.89-.99	.64-.92	8.36-58.6	.09-.37	80.7%-96.7%	4.3%-15.6%
Test Item Cluster (Crank Test, Apprehension Test, Jobe Relocation Test, Anterior Load and Shift Test, and Sulcus Sign Test)□ for Bankar/Anterior Labral Tear[33]	Positive findings for all five tests are necessary: apprehension or an audible click for the Crank test, apprehension for the Apprehension test, elimination of apprehension for the Jobe Relocation test, and excessive translation for the anterior load and shift test and sulcus sign tests.	.85	.90	6.0	.12	75.0%	7.0%
Jerk Test for Posterior/Posterior-Inferior Labral Lesion[44]	Sharp pain and/or click/clunk with described test procedure.	.98	.73	36.5	.28	94.8%	12.3%
Kim Test for Posterior/Posterior-Inferior Labral Lesion[44]	Sharp pain and/or click/clunk with described test procedure.	.94	.80	13.3	.21	86.9%	9.5%
Biceps Load Test I for SLAP Lesion[45]	Apprehension in external rotation or pain with resisted bicep contraction during described test procedure.	.97	.90	30	.10	93.8%	5.3%
Biceps Load Test II for SLAP Lesion[46]	Pain with resisted bicep contraction during described test procedure.	.97	.90	30	.10	93.8%	5.3%
Posterior Impingement Sign for Articular-Sided Internal Impingment Syndrome[52]¶	Deep posterior pain is elicited in 90^0 to 110^0 of abduction, slight extension, and maximal external rotation.	1.0	.95	NA	.05	NA	2.4%

*Specificity
†Sensitivity
‡Positive likelihood ratio
§Negative likelihood ratio
□This test item cluster has been studied in the detection for any anterior glenoid capsulolabral tear, including but not limited to a Bankart Lesion. This data is not specific to the Bankart lesion alone.
¶This data set is only for individuals that have had non-contact injuries with a gradual pain onset.

glenohumeral pathology. The data for the proposed posterior/posterior-inferior instability and labral lesion tests are presented in Table 4.

The Jerk test[44] and the Kim test[44] have the best statistical utility data that met the proposed post-test probability parameters. Post-test probabilities for the above tests are 94.8% and 86.9%, respectively. The post-test probabilities that the patient will exhibit posterior/posterior-inferior glenohumeral instability and/or a labral lesion when the above tests do not indicate such are respectively 12.3% and 9.5%. The QUADAS score is 11 for the article in which statistical data was attained and calculated for these post-test probability statistics.[44]

Special tests that have reported data for posterior/posterior-inferior instability and labral lesion tests that fail to consistently meet the diagnostic threshold for use in this study include the Posterior slide test[3] and the Posterior load and shift test.[3,31]

D. SLAP Lesions

Testing for this pathology is indicated with a positive IRRST (IR MMT << ER MMT) and other appropriate signs and symptoms suggested by a recognizable pattern formed in the initial hypothesis for a SLAP lesion. The data for the proposed SLAP lesion tests are presented in Table 4.

The Biceps load test I[45] and II[46] have the best statistical utility data that met the proposed post-test probability parameters. Post-test probabilities are 93.8% for each of these tests. The post-test probabilities that the patient will exhibit a SLAP lesion when the above tests do not indicate such are 5.3% for each of these tests. The QUADAS scores are 9 and 11 respectively, for the articles in which statistical data was attained and calculated for these post-test probability statistics.[45,46]

Special tests with reported data for SLAP lesions that fail to consistently meet the diagnostic threshold for use in this study included the compression rotation test,[34,38] the O'Brien test,[34,35,38,41,42,43,47,48] the Jobe relocation test,[34,35,42,47] the Speed test,[34,35,42,47,49] the Yergason test,[34,35,42,49] the pain provocation test,[40,41] the anterior slide test,[34,38,37,42] the biceps tenderness test,[34,35,47] the resisted supination external rotation test,[41] the Neer test,[34,42] the Hawkins-Kennedy test,[34,42] the SLAP Prehension test,[50] the hourglass test,[52] the anterior apprehension test,[35] the fulcrum test,[34] the forced shoulder abduction test,[34] the modified Jobe relocation test,[51] and Ellman's test.[34]

E. Articular-Sided Rotator Cuff Internal Impingement Syndrome

Testing for this pathology is indicated with a positive IRRST (ER MMT >> IR MMT) and other appropriate signs and symptoms suggested by a recognizable pattern formed in the initial hypothesis for internal impingement syndrome. The data for the proposed internal impingement syndrome tests are presented in Table 4.

The posterior impingement sign[52] has the best statistical utility data that met the proposed post-test probability parameters. Post-test probability with a positive test is approximately 100%. The post-test probability that the patient will exhibit symptoms of internal impingement syndrome when the above test is negative is 2.4%. This article presents the only known research with data on the statistical profile for identification of internal impingement of the articular side of the rotator cuff at this time. It has also been hypothesized that positive traditional rotator cuff impingement syndrome testing and a positive IRRST for an intra-articular lesion may combine to suggest internal impingement syndrome[8]. The QUADAS score is 7 for the article in which statistical data was attained and calculated for these post-test probability statistics.[52]

EXTRA-ARTICULAR PATHOLOGY

A. LHB Tendinopathy/Tendinosis

Testing for this pathology is indicated with appropriate signs and symptoms suggested by a recognizable pattern formed in the initial hypothesis for LHB tendinopathy. LHB tendinopathy may be an isolated pathology, in which case the IRRST screening test would be inconclusive. If LHB tendinopathy is coupled with subacromial impingement or a SLAP lesion, a positive IRRST screening test may be possible. LHB tendinopathy may include a positive IRRST for rotator cuff pathology (IR MMT >> ER MMT) along with all other appropriate signs and symptoms suggesting LHB tendinopathy. LHB tendinopathy may also include a positive IRRST (IR MMT << ER

Table 5. *Statistical Data for Selected Extra-Articular Pathology Special Tests.*

Test	Applicable Findings	Sp*	Sn†	+LR‡	-LR§	+Post-Test Probability	-Post-Test Probability
Yergason's Test for LHB Tendinopathy[49,53]	Pain is produced in the bicipital groove.	.58-.79	.43-.74	1.76-2.05	.45-.72	46.8% -50.6%	18.4%-26.5%
Speed Test for LHB Tendinopathy[14,49,54]	Pain is elicited with testing in the proximal shoulder.	.14-.75	.32-.90	1.0-1.28	.71-.91	33.3% -39.0%	26.2%-31.3%
Gilcrest Palm-Up Test for LHB Tendinopathy[12,14]	Pain is elicited with testing in the proximal shoulder.	.35-.58	.63-.74	.97-1.76	.45-1.06	32.7% -46.8%	18.4%-34.6%
Test Item Cluster for AC Joint Pathology[55]	All three of the following tests are positive: Cross-Body Adduction test, AC Resisted Extension Test, and the O'Brien's Test.	.97	.25	8.3	.77	80.5%	27.8%

*Specificity
†Sensitivity
‡Positive likelihood ratio
§Negative likelihood ratio

MMT) if associated with a SLAP lesion, along with all other appropriate signs and symptoms suggesting LHB tendinopathy. The data for the proposed LHB tendinopathy tests are presented in Table 5.

The Yergason's test,[49,53] the Speed test,[14,49,54] and the Gilcrest palm-up[12,14] test have the best statistical utility closest to the proposed post-test probability parameters. Post-Test probabilities with a positive Yergason's test range from 46.8% to 50.6%, from 33.3% to 39.0% with a positive Speed test, and from 32.7% to 46.8% with a positive Gilcrest Palm-Up Test. The post-test probabilities that the patient will exhibit an LHB lesion when the above tests do not indicate such range from 18.4% to 26.5% with the Yergason's test, from 26.2% to 31.3% with the Speed test, and from 18.4% to 34.6% with the Gilcrest Palm-Up Test. Because the proposed post-test parameters have not been met, diagnostic threshold at this time is proposed to be reproduction of the patient's primary complaint with positive results for two of the three above-mentioned tests (please note that this a proposed solution only, and that these tests have not been studied as a TIC). QUADAS scores range from 7-11 for the articles in which statistical data was attained and calculated for these post-test probability statistics.[12,14,49,53,54] These five articles are the only known to have statistical data for the presence of isolated LHB lesions (lesions that are found in the LHB that may or may not be in the presence of subacromial impingement syndrome and/or SLAP lesions).

B. AC Joint Pathology

Testing for this pathology is indicated with appropriate signs and symptoms suggested by a recognizable pattern formed in the initial hypothesis for an AC joint lesion as well as an inconclusive IRRST. The data for the proposed AC joint lesion tests are presented in Table 5.

The TIC that includes the cross-body adduction test, the AC resisted extension test, and the O'Brien's test have the best statistical utility closest to the proposed post-test probability parameters.[55] Post-Test probability when all three tests are positive per the Test Item Cluster (TIC) is 80.5%. The post-test probability that the patient will exhibit an AC joint lesion when the TIC does not indicate such is 27.8%. Because the proposed post-test parameters have not been met, diagnostic threshold at this time is proposed to be reproduction of the patient's primary complaint in conjunction with a positive TIC as described. The QUADAS score is 10 for the article in which statistical data was attained and calculated for these post-test probability statistics.[55]

Special tests that have also reported data for AC joint pathology that fail to consistently meet the diagnos-

tic threshold and have inferior data sets to the TIC included the O'Brien test,[48,55,56] the Paxino test,[56] AC joint palpation,[56] the cross-body adduction test,[55] the AC resisted extension test,[55] the Neer test,[55] the Hawkins-Kennedy test,[55] the painful arc sign,[55] the drop arm sign,[55] and the Speeds test.[55]

RESULTS

II. Statistical Analysis of the Proposed Evidence-Based Shoulder Special Testing Examination Algorithm

Achievement of proposed statistical diagnostic threshold parameters was accomplished in 6 pathological shoulder conditions; 3 pathological shoulder conditions did not achieve these criteria.

Figure 2 summarizes the proposed shoulder examination algorithm special test classifications that may be divided by both pattern recognition and an initial screening test.

In the proposed shoulder examination algorithm, 15 of 26 tests achieved the proposed statistical diagnostic threshold parameters. Eleven tests were included in three different Test Item Cluster data sets. One TIC data set that included three special tests met the proposed statistical diagnostic threshold when they otherwise would not have in isolation. Special testing data for rotator cuff impingement syndrome, rotator cuff integrity, anterior capsulolabral instability, posterior/posterior-inferior capsulolabral instability and labral lesions, SLAP lesions, and internal impingement syndrome all had sufficient clinical utility data to achieve successful diagnosis of these conditions within the set parameters of this manuscript. Special testing data for detection of acromioclavicular joint lesions, tendinopathy of the LHB, and Bankart lesions did not meet these parameters. A summary of the data sources for selected special tests used in this examination algorithm is given in Table 6.

DISCUSSION

One other known comprehensive systematic review of shoulder special testing statistical analysis has been previously performed. Most, but not all, special tests in this manuscript were included in the previously published systematic review. Forty-five studies were evaluated, with half meeting quality standards of the previously published systematic review, which were defined as a score of at least 10 on the QUADAS tool. Specificity, sensitivity, positive and negative likelihood ratios were inclusive in this previous study. Also inclusive in the previous study were well defined sample sizes that were deemed adequate, sufficient heterogeneity between studies deemed appropriate, and exclusion of studies that were deemed not be sufficiently reported on. Test Item Clusters, pre-test probability, diagnostic threshold, and post-test probability were not inclusive in the previously published systematic review. Due to the variety of differences in acceptance of certain studies and associated special tests therein, differences in suggested use have resulted between the

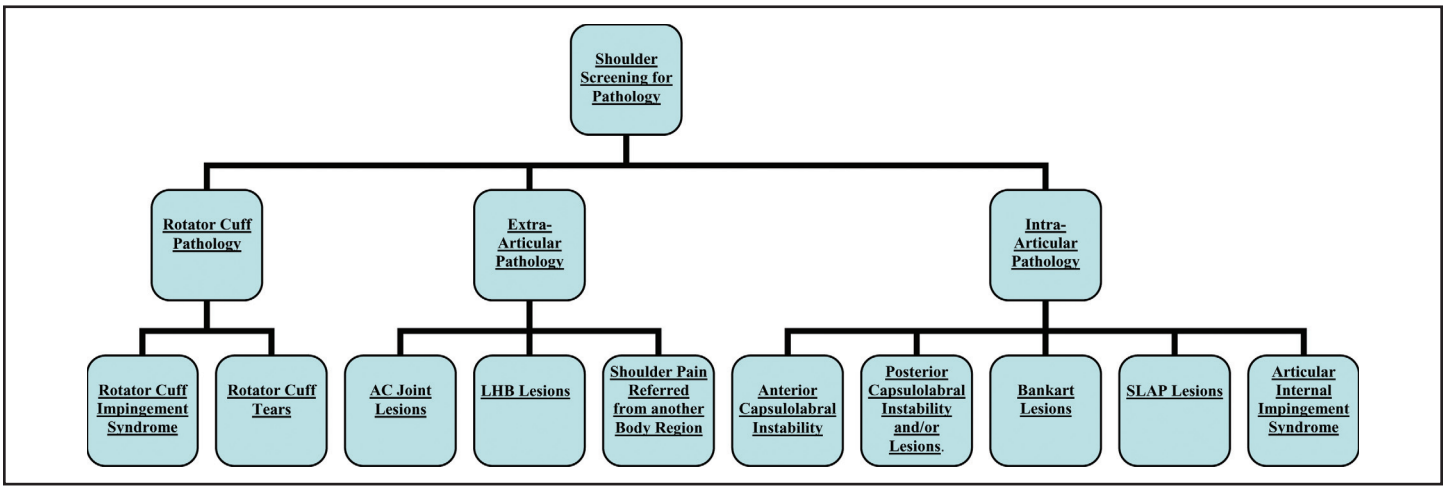

Figure 2. *Flow chart of algorithm based examination process. Rotator cuff pathology, extra-articular pathology, and intra-articular pathology are further subdivided into common shoulder conditions that may be differentially diagnosed.*

Table 6. *Data Summary of the 17 Articles Yielding Diagnostic Statistics for the 26 Special Tests Included in the Shoulder Examination Algorithm.*

Special Test	Citation	Test Category	N	Reference Standard	Sp*	Sn†	LR+‡	LR-§	+Post-Test Probability	-Post-Test Probability
IRRST	Zaslav (8)	Screening Test	110	Surgical Observation	0.96	0.86	0.86	0.13	91.7%	6.10%
Rotator Cuff Impingement TIC□ (3/3)	Park et al (9)	RTC Impingement	552	Surgical Observation	NR	NR	10.56	NR	95.5%	NR
Rotator Cuff Impingement TIC□ (2/3)	Park et al (9)	RTC Impingement	552	Surgical Observation	NR	NR	5.03	NR	91.0%	NR
ERLS	Hertel et al (16)	RTC (Supraspinatus and/or Infraspinatus) Tear	87	Surgical Observation	0.69	0.98	15.50	0.32	88.8%	13.80%
ERLS	Walch et al (17)	RTC (Supraspinatus and/or Infraspinatus) Tear	87	Surgical Observation	0.98	0.98	34.50	0.02	94.5%	9.10%
Dropping-Sign	Walch et al (17)	RTC (Infraspinatus) Tear	87	Surgical Observation	1.00	1.00	0.00	0.00	100.0%	NA
Hornblower's Sign	Walch et al (17)	RTC (Teres Minor) Tear	87	Surgical Observation	0.93	1.00	14.29	0.00	87.7%	NA
IRLS	Hertel et al (16)	RTC (Subscapularis) Tear	54	Surgical Observation	0.96	0.97	24.30	0.03	92.4%	1.48%
Apprehension Test	Lo et al (29)	Anterior Instability	46	Radiograph	0.99	0.53	20.20	0.47	91.0%	12.70%
Apprehension Test	Farber et al (28)	Anterior Instability	363	Surgical Observation	0.96	0.72	53.00	0.47	96.4%	19.00%
Anterior Release (Surprise) Test	Lo et al (29)	Anterior Instability	46	Radiograph	0.99	0.64	8.36	0.37	80.7%	15.60%
Anterior Release (Surprise) Test	Gross et al (30)	Anterior Instability	100	Surgical Observation	0.89	0.92	58.60	0.09	96.7%	4.30%
Anteior Labral Tear TIC□	Liu et al (33)	Bankart Lesion/Anterior Labral Tear	62	MRI	0.85	0.90	6.00	0.12	75.0%	7.00%
Jerk Test	Kim et al (44)	Posterior Instability/Labral Tear	172	Surgical Observation	0.98	0.73	36.50	0.28	94.8%	12.30%
Kim Test	Kim et al (44)	Posterior Instability/Labral Tear	172	Surgical Observation	0.94	0.80	13.30	0.21	86.9%	9.50%
Biceps Load Test I	Kim et al (45)	SLAP¶ Lesion	75	Surgical Observation	0.97	0.90	30.00	0.10	93.8%	5.30%
Biceps Load Test II	Kim et al (46)	SLAP¶ Lesion	127	Surgical Observation	0.97	0.90	30.00	0.10	93.8%	5.30%
Posterior Impingement Sign	Meister et al (52)	Articular Internal Impingement	69	Surgical Observation	0.85	0.76	5.00	0.29	71.4%	2.40%
Yergason's Test	Naredo et al (14)	LHB# Tendinopathy	31	Ultrasonography	0.58	0.74	1.76	0.45	46.8%	26.50%
Yergason's Test	Holtby et al (49)	LHB# Tendinopathy	50	Surgical Observation	0.79	0.43	2.05	0.72	50.6%	18.40%
Speed Test	Bennett (14)	LHB# Tendinopathy	46	Surgical Observation	0.14	0.90	1.00	0.71	33.3%	31.30%
Speed Test	Holtby et al (49)	LHB# Tendinopathy	50	Surgical Observation	0.75	0.90	1.28	0.91	39.0%	26.20%
Gilcrest Palm-Up Test	Leroux (12)	LHB# Tendinopathy	55	Surgical Observation	0.35	0.63	0.97	1.06	32.7%	34.60%
Gilcrest Palm-Up Test	Naredo et al (14)	LHB# Tendinopathy	31	Ultrasonography	0.58	0.74	1.76	0.45	46.8%	18.40%
AC** Joint TIC□ (3/3)	Chronopoulos et al (55)	AC** Joint Lesion	325	AC Joint Injection	0.97	0.25	8.30	0.77	80.5%	27.80%

*Specificity
†Sensitivity
‡Positive likelihood ratio
§Negative likelihood ratio
□Test Item Cluster
¶Superior Labrum Anterior Posterior
#Long Head of the Biceps
**Acromioclavicular

previous study and this manuscript. Aside from differences in selection parameters in the previously published systematic review and the parameters for selection in this manuscript, many similar thoughts and opinions are shared. Of these, a great lack of consistency with regard to how, when, and what special tests to use in clinical examination for shoulder differential diagnosis is evident.[57]

CONCLUSION

In need at this time are large, randomized controlled trials that include patient history and all facets of physical examination. This special testing algorithm is meant to be modifiable for the future, as studies with better statistical data emerge for specific special tests and/or categories of shoulder diagnosis. Special testing should, in the author's opinion, simply should be an affirmation of expected diagnosis in a differential manner after conclusion of all other portions of the examination has been completed. Should diagnostic physical examination testing become more statistically accurate, it is very possible that improved research can be accomplished for items such as establishing clinical practice guide-

lines to help guide examination, treatment, patient management, and improve patient outcomes.

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