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The value of physical tests for subacromial impingement syndrome: a study of diagnostic accuracy

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Objective: To determine the diagnostic accuracy of commonly used physical tests for subacromial impingement syndrome, using ultrasound as the reference standard.
Design: A cross-sectional study of 59 participants with chronic shoulder pain of more than four months duration with a referral for diagnostic ultrasound scanning were invited to participate in the study.
Main measures: Thirty-four participants met the inclusion criteria and had an ultrasound scan followed immediately by application of the following tests: Neer's sign, Hawkins and Kennedy test, painful arc of abduction, empty and full can tests, resisted isometric shoulder abduction and resisted isometric shoulder external rotation. Using the two-way contingency table method sensitivity, specificity, likelihood ratios and overall accuracy were calculated for each physical test.
Results: Diagnostic values for each test varied considerably. The Hawkins and Kennedy test was the most accurate test for diagnosing any degree of subacromial impingement syndrome (71.0%). The most accurate tests for diagnosing subcategories of impingement were pain on resisted external rotation and weakness during the full can test (63.6%) for presence of subdeltoid fluid, pain on resisted external rotation (58.8%) for partial thickness tears and the painful arc test (62.1%) for full thickness tears.
Conclusions: As the predictive values of these tests are shown to be variable in this study it indicates that the clinical tests identified have limited use in informing diagnosis. Emphasis on the management of dysfunction may be more appropriate rather than reliance on clinical tests with inconclusive sensitivity and specificity if ultrasound scanning is not available.

Introduction

The shoulder impingement concept is extremely complex. Subacromial impingement syndrome exists as an association of various comorbidities around the shoulder, each exhibiting different clinical signs and symptoms.[1] This may explain the overall lack of consensus on diagnostic criteria. Subacromial impingement syndrome manifests in the subacromial space when the subacromial bursa and rotator cuff become entrapped between the humeral head and acromion or coracoacromial ligament due to pathomechanics or inflammatory or osseous protrusions into the subacromial space (Figure 1). Progression of subacromial

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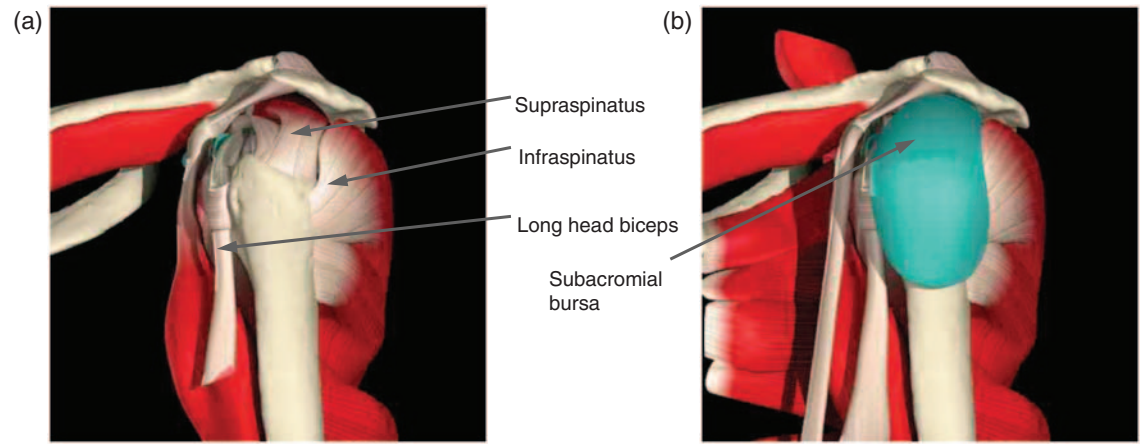

Figure 1 Structures involved in subacromial impingement. (a) Muscles under the acromion process; (b) subacromial bursa. (Reproduced with permission from Primal Pictures Limited.).

impingement syndrome is usually classified according to the inflammatory or degenerative state of the rotator cuff and bursa.[2]

Several physical tests for diagnosing subacromial impingement syndrome and integrity of the rotator cuff have been identified.[3] A meta-analysis on the accuracy of such tests indicates that physical examination may be useful at ruling out rotator cuff disorders (high sensitivity) but less accurate at specifying the exact structure at fault (low specificity).[3] An issue with previous studies is the time delay between performance of the index and reference tests, which may not take into account the possible progression of pathology. Many of the studies to date have used arthroscopic procedures as the reference test,[4–11] hence they have excluded a subset of patients whose condition does not warrant arthroscopic intervention.

The aim of this study is to determine the diagnostic accuracy of physical tests for subacromial impingement syndrome in non-surgical candidates, using ultrasound as the reference standard. Advances in diagnostic ultrasound equipment together with increasing expertise of radiologists have established ultrasound as an accurate technique for the evaluation of soft tissue pathology. A high degree of accuracy in the diagnosis of cuff tears and subacromial impingement syndrome with ultrasound scanning has been demonstrated, supporting its use as the reference standard in this study.[12,13]

Methods

This cross-sectional study of diagnostic accuracy was conducted as an extension of outpatient appointments for ultrasound scanning of the shoulder. Patients were referred for ultrasound scan prior to consideration of surgical or conservative management. Eighty consecutive patients attending an orthopaedic hospital between June and September 2006 were considered for inclusion into the study. Patients were sent an information sheet about the study with their ultrasound appointment details and asked to return a reply slip if they were willing to consider participation. Final screening was conducted with the patient on attendance at the clinic for their ultrasound scan and they were given the opportunity to ask questions. Patients aged between 20 and 70 years, with the ability to follow instructions and no history of traumatic injury to the shoulder were deemed eligible for the study. Those with neurological-type pain or weakness originating from the cervical spine, or inflammatory joint disease were excluded. Approval for the study was gained from the Local Research Ethics Committee.

The physical examination comprised seven physical tests commonly used to evaluate subacromial impingement syndrome and shoulder dysfunction. Each patient was examined by the same physiotherapist immediately after the ultrasound scan. The physiotherapist was blinded to the results of the ultrasound scan. To standardize replication of the tests the physiotherapist received prior training and performed the tests in the same order, with the tests placing increasing stress and more likely to cause irritation and possible influence subsequent tests being performed last. The reliability and reproducibility of Neer's sign, Hawkins and Kennedy test, weakness in resisted abduction/external rotation and the painful arc have been reported elsewhere.[14]

Execution of the tests

Neer's sign

In standing the patient's arm was passively elevated in the plane of the scapula while preventing rotation of the scapula. Reproduction of pain at the anterior edge of the acromion/lateral deltoid was considered a positive response for impingement.[15]

Hawkins and Kennedy test

While sitting, with the elbow flexed to 90°, the patient's shoulder was passively elevated to 90° in the sagittal plane and then forcefully rotated medially. Pain indicated a positive test result.[16]

Painful arc of abduction

While standing, with the shoulder in external rotation (palm facing up), the patient was asked to abduct the arm and report the occurrence of pain.[17] The test was considered positive if pain was experienced between 60° and 120°,[18] above or below which movement was pain free.

Empty and full can tests

While standing, the patient was instructed to abduct the arm to 90° in the plane of the scapula and with the elbow in full extension, rotate the shoulder medially by pointing the thumb downward (empty can test). The examiner then applied a uniform downward force to the upper surface of the arm just above the elbow, asking the patient to resist the pressure.[19] This test was replicated with the thumb pointing upwards (full can test).[20] Pain or weakness indicated a positive test.

Resisted isometric abduction

While standing, with the elbow extended and arm in neutral rotation, the patient abducted the arm to 90°. The patient was asked to maintain this position as the examiner applied a downward force to the lateral aspect of the arm, proximal to the elbow.[21] Pain or weakness indicated a positive test.

Resisted isometric external rotation

While standing, with the shoulder in neutral rotation and the elbow flexed to 90°, the patient was asked to externally rotate the shoulder by taking the hand away from the side of the body. The patient was asked to maintain this position as the examiner applied internal force to the posterior aspect of the forearm, proximal to the wrist.[21] Pain or weakness indicated a positive test.

If the patient was unable to fully complete any of the tests no result was recorded and the patient was excluded from analysis of that test.

Ultrasound evaluation

Ultrasonography was performed by a consultant radiologist (GMA), with extensive experience in musculoskeletal ultrasonography, particularly of the shoulder. The examinations were performed on a Philips HDI 5000 machine with a 5–12 MHz linear array probe. A standard technique as outlined by the European Society of Musculoskeletal Skeletal Radiology ultrasound subcommittee was used for all testing.[22]

Ultrasonography was performed with the patient in sitting with their arm in four positions: (a) palm face-up on their knee to visualize the long head of biceps tendon, (b) elbow tucked into their side with external rotation of the shoulder to visualize subscapularis, (c) hand in the small of the

back with palm facing outwards to visualize the supraspinatus tendon and (d) hand placed on the opposite shoulder to visualize the infraspinatus tendon. Scanning was conducted from behind the patient, with the scan plane along the line of each tendon and at 90 degrees to the tendon.

Diagnostic criteria for ultrasonography are identified in Table 1. Further information can be found in a review article by Allen and Wilson.[23] Figure 2 shows examples of full and partial thickness tears of the supraspinatus tendon.

Statistical analysis

SPSS 14.0 for Windows (SPSS Inc., Chicago, IL, USA) was used for all statistical analyses. Sensitivity, specificity, likelihood ratios and overall accuracy were calculated for all seven physical tests using the two-way contingency table method.[24] The analysis was performed to evaluate the diagnostic value of the tests for any degree of subacromial impingement syndrome. Impingement was then divided into three subcategories and the analysis was repeated. Subcategories were identified as: full thickness tear with or without subdeltoid fluid, partial thickness tear with or without subdeltoid fluid and presence of subdeltoid fluid only. Likelihood ratios of greater than 10 were considered sufficient to rule in the target condition.[24]

Results

Of the 80 individuals who were referred for diagnostic ultrasound scanning of their shoulder, 59 met the inclusion criteria. Of those consenting to participate in the study ($n = 38$), four individuals

Table 1 Criteria for ultrasonography diagnosis

Diagnosis	Criteria
Full thickness tear (FFT)	Loss of convex upper surface (SSP or ISP) Visible tear from bursal to undersurface of tendon (SSP or ISP) Complete tear with tendon retraction and no visible tendon inserted into greater tuberosity (SSP or ISP)
Partial thickness tear (PTT)	Bursal surface partial thickness tear (SSP or ISP) Under-surface partial thickness tear (SSP or ISP)
Subacromial/subdeltoid bursitis (SDF)	Subacromial/subdeltoid fluid

SSP, supraspinatus tendon; ISP, infraspinatus tendon.

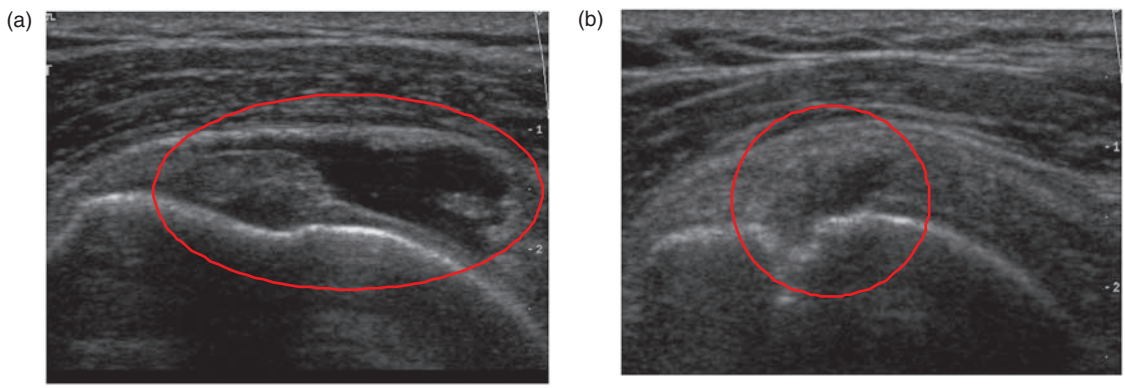

Figure 2 Ultrasound images of supraspinatus tendon. (a) Full thickness tear; (b) partial thickness tear.

were excluded for the following reasons: communication problems ($n=1$), cervical spine injury ($n=1$), poor ultrasound visualization ($n=1$) and failure to attend physiotherapy assessment ($n=1$). The remaining 34 individuals (20 male and 14 female) constituted the final study group. The median age of participants was 57 years (interquartile range 44–63) and the median duration of their symptoms was 2 years (interquartile range 1–4).

Results of ultrasound scanning on the symptomatic shoulder identified 11 full thickness tears (8 of which also presented subacromial bursitis), 7 partial thickness tears (6 of which also presented with bursitis) and 12 cases of bursitis only. On one occasion there was difficulty distinguishing whether or not a full thickness tear was present, hence the ultrasound diagnosis was marked as unclear and excluded from the overall analysis, where one or more positive results from the ultrasound scan were required to indicate a positive test. Also, limited motion or extreme pain during physical testing prevented complete execution of individual physical tests as follows: Hawkins and Kennedy ($n=2$), painful arc ($n=4$), and empty can ($n=3$). Participants with an unclear ultrasound diagnosis and/or incomplete physical tests were excluded from analysis for the respective tests.

The diagnostic values of the physical tests for an overall diagnosis of subacromial impingement syndrome by ultrasound are summarized in Table 2. There appears to be a trade-off between sensitivity and specificity of the physical tests, hence reducing their diagnostic power. Pain on resisted external rotation was the strongest indicator of subacromial impingement syndrome (specificity = 100%), however the low sensitivity (34.5%), means that subacromial impingement syndrome cannot be dismissed if the test result is negative. In contrast, absence of pain during the Hawkins and Kennedy test may be useful for ruling out subacromial impingement syndrome (sensitivity = 74.1%), however a positive test is only 50% likely to be caused by impingement. The diagnostic values of the physical tests for subcategories of subacromial impingement syndrome identified with ultrasound are summarized in Table 3, with all available individual ultrasound results for the three different categories being included.

The physical tests were reasonably sensitive, however their overall accuracies were compromised by low test specificities, none of which exceed 50%. Likelihood ratios showed that patients with the target conditions were no more than 1.5 times as likely to have a positive test result compared with those without the condition.

Table 2 Diagnostic values of the physical tests for any degree of subacromial impingement syndrome, using ultrasound as the reference standard

Physical tests	*n*	Ultrasound positive		Ultrasound negative		Sensitivity (%)	Specificity (%)	Accuracy (%)	Likelihood ratio
		Test positive	Test negative	Test positive	Test negative				
Neer's sign	33[a]	18	11	4	0	62.1	0.0	54.5	0.62
Hawkins and Kennedy	31[a,b]	20	7	2	2	74.1	50.0	71.0	1.48
Painful arc	29[a,b]	9	19	0	1	29.6	50.0	31.0	0.59
Abduction weakness	33[a]	11	18	2	2	37.9	50.0	39.4	0.76
Abduction pain	33[a]	16	13	1	3	55.2	75.0	57.6	2.21
External rotation weakness	33[a]	16	13	3	1	55.2	25.0	51.5	0.74
External rotation pain	33[a]	10	19	0	4	34.5	100.0	42.4	∞
Empty can weakness	30[a,b]	14	13	1	2	51.9	66.7	53.3	1.56
Empty can pain	30[a,b]	14	13	2	1	51.9	33.3	50.0	0.78
Full can weakness	33[a]	13	16	1	3	44.8	75.0	48.5	1.79
Full can pain	33[a]	10	19	3	1	34.5	25.0	33.3	0.46

[a]Patients with unclear ultrasound diagnosis were excluded from analysis.
[b]Patients with incomplete physical tests were excluded from analysis.
Ultrasound identified as positive if one or more ultrasound stages of subacromial impingement syndrome scored positive.

Table 3 Diagnostic values of the physical tests for the three different stages of subacromial impingement syndrome, using ultrasound as the reference standard

Ultrasound diagnosis	*n*	Sensitivity (%)	Specificity (%)	Accuracy (%)	Likelihood ratio
Neer's sign					
FTT	33[a]	45.5	22.7	30.3	0.59
PTT	34	72.7	17.4	35.3	0.88
SDF	33[a]	72.7	40.9	51.5	1.23
Hawkins and Kennedy					
FTT	31[a,b]	66.7	36.4	45.2	1.05
PTT	32[b]	55.6	13.0	25.0	0.64
SDF	31[a,b]	88.9	40.9	54.8	1.50
Painful arc					
FTT	29[a,b]	70.0	44.4	62.1	1.26
PTT	30[b]	75.0	20.0	56.7	0.94
SDF	29[a,b]	55.0	22.2	44.8	0.71
Abduction weakness					
FTT	33[a]	65.0	30.8	51.5	0.94
PTT	34	75.0	14.3	50.0	0.88
SDF	33[a]	65.0	38.5	54.5	1.06
Abduction pain					
FTT	33[a]	75.0	41.2	57.6	1.28
PTT	34	68.8	11.1	38.2	0.77
SDF	33[a]	68.8	41.2	54.5	1.17
External rotation weakness					
FTT	33[a]	64.3	31.6	45.5	0.94
PTT	34	71.4	15.0	38.2	0.84
SDF	33[a]	64.3	36.8	48.5	1.02
External rotation pain					
FTT	33[a]	65.2	30.0	54.6	0.93
PTT	34	78.3	18.2	58.8	0.96
SDF	33[a]	69.6	50.0	63.6	1.39
Empty can weakness					
FTT	30[a,b]	60.0	33.3	46.7	0.90
PTT	31[b]	75.0	13.3	45.2	0.87
SDF	30[a,b]	73.3	46.7	60.0	1.38
Empty can pain					
FTT	30[a,b]	64.3	37.5	50.0	1.03
PTT	31[b]	73.3	12.5	41.9	0.84
SDF	30[a,b]	64.3	37.5	50.0	1.03
Full can weakness					
FTT	33[a]	68.4	35.7	54.5	1.06
PTT	34	70.0	7.1	44.1	0.75
SDF	33[a]	73.7	50.0	63.6	1.47
Full can pain					
FTT	33[a]	65.0	30.8	51.5	0.94
PTT	34	70.0	7.1	44.1	0.75
SDF	33[a]	65.0	38.5	54.5	1.06

FTT, full thickness tear; PTT, partial thickness tear; SDF, subdeltoid/subacromial fluid.
[a]Patients with unclear ultrasound diagnosis were excluded from analysis.
[b]Patients with incomplete physical tests were excluded from analysis.

For subdeltoid fluid (bursitis) only, the Hawkins and Kennedy test was the most sensitive test (88.9%). Pain on resisted external rotation and weakness during the full can test are the most specific tests (50.0%), and also the most accurate predictors of subdeltoid fluid with no tear (63.6%).

For patients with partial thickness tears, pain on resisted external rotation was the most sensitive

(78.3%) and also the most accurate (58.8%) test. The most specific test was the painful arc (20.0%).

The most sensitive test for diagnosing full thickness tears was pain on resisted abduction (75%). The most specific test was the painful arc test (44.4%). This was also the most accurate test for diagnosing full thickness tears (62.1%).

Discussion

The results suggest that the physical tests investigated are not very accurate for diagnosing different stages of subacromial impingement syndrome. The tests proved to be more sensitive for diagnosing bursitis compared with rotator cuff tears. This may be because free nerve endings are more richly supplied in the subacromial bursa than in the rotator cuff tendons. Pain relating to the bursa is therefore more likely to be detected.[8]

Most of the physical tests were reasonably sensitive but lacked specificity suggesting that comorbidities such as glenoid labrum lesions and arthritis may have been the cause of symptom reproduction on testing.[10,11] In contrast, patients may have had subacromial impingement syndrome but no visible signs on ultrasound testing, as the irritation was not at a sufficient level to cause pathological change. In a study on arthroscopic management of rotator cuff disease, Gartsman,[25] highlighted that many people have painful impingement without incitement of any inflammatory reaction. The positive physical test results on some asymptomatic shoulders in our study support this finding and may be an early indication of developing pathology. Alternatively, it may reflect the subjectivity of physical tests and be caused by inaccurate patient interpretation of pain.

Periarticular shoulder lesions, especially rotator cuff tears have been reported in asymptomatic shoulders.[26] The positive ultrasound results on some asymptomatic shoulders in our study support this finding. Further investigation of the physical tests on asymptomatic shoulders is warranted to inform clinical practice.

Ultrasound is considered to be less accurate than arthroscopy and open surgery for detecting rotator cuff lesions, however accuracies of greater than 0.85 have been found for ultrasound diagnosis when compared against surgical findings.[27] Ultrasound also has considerable advantages over other reference testing as there are fewer contraindications, the examination is non-invasive, quick and easy to perform, allows for dynamic testing and the cost is comparatively low. Ultrasound has been used as the reference test for determining the diagnostic accuracy of physical tests for subacromial impingement syndrome.[27] This study differed from the current study as patients were grouped by different ultrasound diagnoses and compared with diagnoses established by the consensus of two rheumatologists, using selected tests for each condition. Also, a delay of up to one week between physical and ultrasound testing may have produced variability in the presentation of symptoms at each assessment. Comparison between studies is therefore difficult. However they did similarly conclude that the clinical diagnosis of periarticular conditions in the painful shoulder by physical tests is not very accurate compared with ultrasound diagnoses.

Other studies have reported variable sensitivities and specificities for physical tests as identified in Table 4. These studies used MRI and arthroscopy as reference tests. Lack of specification of time delay between the index and reference tests is also evident. Consequently their sample population differs from ours and comparison of results is problematic. Comparison between studies in relation to physical tests is complicated further as details of the criteria used to determine positive tests are not consistently available.

The study reported here suggests that the physical examinations varied according to the stage of pathological changes of subacromial impingement syndrome. Although few studies actually examine the diagnostic value of physical tests for each stage of impingement, a similar relationship was found in the study by Park *et al*.[24] They also found that accuracy can be improved by increasing the number of combinations of tests. Owing to the small sample size in our study it was not possible to replicate the logistic regression analysis performed by Park *et al*.[24] to see if the same would be true in the patient population we studied.

In our study all of the participants were suspected of having subacromial impingement

Table 4 Summary of published values for sensitivity and specificity of physical tests for subacromial impingement syndrome

Study	*n*	Reference test	Time delay between index and reference test	Results – sensitivity, specificity (%)									
				Hawkins		Neer		Painful arc		Supraspinatus test (empty can)		Infraspinatus test (resisted external rotation)	
				Se	Sp	Se	Sp	Se	Sp	Se	Sp	Se	Sp
Calis *et al.*[28]	125	MRI	Unclear	92	25	89	31	33	81	n/a	n/a	n/a	n/a
Park *et al.*[24]	359	Arthroscopy	<4 weeks	72	66	68	69	74	81	44	90	42	90
MacDonald *et al.*[10]	85	Arthroscopy	Unclear	69	60	77	63	n/a	n/a	n/a	n/a	n/a	n/a
Parentis *et al.*[11]	132	Arthroscopy	Unclear	83	n/a	57	n/a	n/a	n/a	n/a	n/a	n/a	n/a

n/a, not available; Se, sensitivity; Sp, specificity.

syndrome of the symptomatic shoulder. Future studies should include a control group sample to allow full evaluation of the accuracy of physical test procedures.

It would be useful to be able to categorize subacromial impingement syndrome before the patient reaches the stage at which they need surgical intervention. This would allow better evaluation of their prognosis and would allow researchers developing conventional treatment protocols, to evaluate how different types of shoulder pathology respond to various forms of therapeutic management.

A limitation of this study was the relatively small sample size. Although larger studies with control populations would be needed to establish the strength of evidence, our results suggest that the tests used in this study are not able to accurately diagnose subacromial impingement syndrome during the pre-surgical stage of medical management. Technological advances in equipment and increasing experience of musculoskeletal ultrasonographers have improved ultrasound diagnosis, but the problem of accessing all relevant structures related to subacromial impingement syndrome with ultrasound limits the value of ultrasound as an absolute reference standard. Based on the findings of rotator cuff changes in asymptomatic patients,[26] treatment should be based on physical findings together with additional information from ultrasound scanning. Our results identify that physical tests have limited diagnostic value and indicate that in the absence of ultrasound scanning, emphasis should be on treatment to redress dysfunction when planning management of subacromial impingement syndrome. To address symptoms of pain muscle weakness and movement dysfunction likely to present as a result of subacromial impingement syndrome, treatment could include pain management, muscle strengthening, muscle balance resetting and retraining of normal, pain-free movement patterns.

Clinical messages

- Lack of specificity identified in clinical tests for diagnosis of subacromial impingement syndrome.
- Ultrasound scans can assist in identification of subacromial impingement syndrome but not able to explore all structures that could cause symptoms.
- Consideration of functional limitations and muscle balance may offer a more appropriate approach to management of subacromial impingement syndrome.

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