

# Diagnostic Accuracy of Clinical Tests To Diagnose Subacromial Impingement Syndrome: A Systematic Review

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## ABSTRACT

### Objectives

The aim of this review was to systematically review the cost-effective diagnostic utility of clinical tests to diagnose subacromial impingement syndrome.

### Data Sources

The following electronic databases: Medline, EMBASE, Science Direct and the Cochrane Library were searched in June 2020 to identify the studies that investigated the diagnostic accuracy of clinical tests to diagnose SAIS. The search was restricted to articles written in English.

### Study Selection

This study included diagnostic accuracy of cohort studies that directly compared the diagnostic utility of clinical tests for diagnosing SAIS against either surgical or indirect imaging reference standards. The PRISMA guidelines were followed to accomplish this review. Two reviewers independently performed the study's methodological quality assessment by using the QUADAS tool.

### Data Extraction

The sensitivity and specificity for each clinical test was extracted from the included studies and both positive and negative likelihood ratios were tabulated either direct from available studies or calculated from the provided sensitivity and specificity data.

### Data Synthesis

This review included 14 studies in total of 1756 shoulders and considered standard, modified and novel clinical tests for making a differential diagnosis on SAIS. In this review, included studies' overall methodological quality is high and there appears to be the diagnostic utility of the subacromial grinding test, lift-off, bear-hug and belly-off tests provide significant evidence to rule in SAIS when the tests are positive.

### Conclusion

This is an updated study of a previous systematic review on the diagnostic accuracy of clinical tests for SAIS. Making a precise differential diagnosis will ultimately ensure the appropriate therapeutic interventions, subsequently successful prognosis on SAIS patients thus, this review findings of diagnostic utility clinical tests need to be considered in the context of clinical practice of the overall patient assessment.

**Keywords:** Subacromial impingement syndrome, Clinical test, Diagnostic utility, Sensitivity and specificity

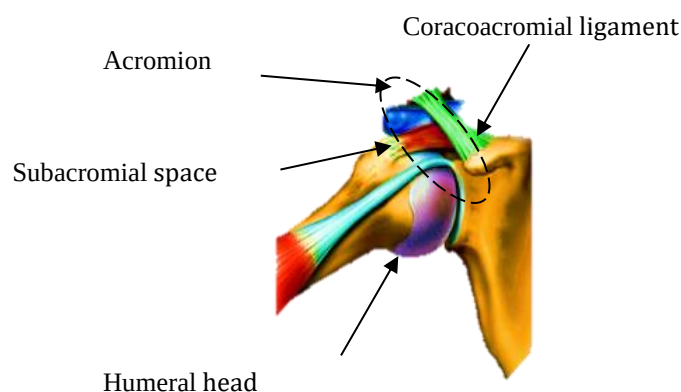
## INTRODUCTION

Musculoskeletal (MSK) disorders significantly contribute to the disability proportion<sup>1</sup> and it impacts people across their life-course in all regions of the world<sup>2</sup>. The incidence of MSK disease increases with aging<sup>3</sup>. A recent research study claimed that between 20%–33% of people across the world live with a painful MSK disorder<sup>4</sup>. Among these wide-spread MSK disorders, shoulder pain is a significant cause of morbidity in any age population, and it has been estimated as the third most common complaint of MSK disorder in primary care clinical setting<sup>5</sup>, where the majority of shoulder pain is conservatively managed<sup>6</sup>. The shoulder pain is estimated that the annual prevalence is up to 46.7% with a lifetime prevalence of up to 66.7%<sup>7</sup>. The highest incidence reported among women aged between 45–64 years old<sup>8</sup>. Besides, the shoulder pain population, Subacromial Impingement Syndrome (SAIS) is considered as the most common pathology of the shoulder pain and accounted for 44%–65% of complaints in primary care consultation<sup>9</sup>. The author Consigliere et al., estimated that shoulder pain incidence is between 20% and 50% in the general practice settings and among these patients one in four were diagnosed as SAIS for the therapeutic interventions and further medical management<sup>10</sup>. The work-related musculoskeletal disorders population surveys showed that shoulder pain disorders have a negative impact on both personal and national levels as the symptoms can be disabling in terms of individual's functional capability<sup>11</sup> and reduced work performance<sup>12</sup>. As a result, both eventually lead to a negative influence on a person's financial capacity, mental wellbeing and withdrawal from social interaction<sup>13</sup>. The SAIS is also associated with other psychosocial factors such as self-efficacy<sup>14</sup>. This has resulted in an expansion of the demands on health care costs and work-related absenteeism that possibly leads to early retirement or losing jobs<sup>13</sup>. These are social concerns<sup>15</sup> because of its wider range of destructive consequences on the global socio-economic developing activities<sup>16</sup>.

### **Description of Condition**

The human shoulder joint involves various physically demanded and a wide range of motion day to day functional activities<sup>11</sup>. To accomplish this requirement, the joint girdle is not a simple 'ball and socket' but a complex and collected of four articulations, which are reinforced by the morphology of bones, ligaments and muscles surrounding the joints<sup>17</sup>. However, the shoulder joint is highly susceptible to a range of articular and peri-articular pathologies because of its complexity and the nature of the functional activity demands on it<sup>18</sup>. Therefore, shoulder pain has a wide range of root causes<sup>9</sup>; in addition to that, shoulder pain may be overlapped from other regional pain (eg: neck conditions) and visceral pathologies (eg: gallbladder) causing symptoms<sup>19</sup>. These complexities challenge clinicians to have a precise differential diagnosis on shoulder pain<sup>12</sup>.

Subacromial Impingement Syndrome has been discussed for decades. In 1972, Neer proposed the term SAIS describing an “inflammation and degeneration of the anatomical structures in the region of the subacromial space”, which is built by the humeral head inferiorly, the anterior lateral third of the acromion and coracoacromial ligament superiorly<sup>20</sup>.



**Figure 01:** Anatomical illustration of SAIS<sup>20</sup>

SAIS is classified into external/subacromial and internal impingement syndrome; the external impingement occurs in the subacromial space, whereas the internal impingement syndrome happens between the posterior portion of the humerus head and the glenoid labrum<sup>21</sup>. SAIS encompasses a spectrum of pathologies including subacromial bursitis, rotator cuff tendinosis either partial or full thickness<sup>20</sup>. The trigger of SAIS is commonly multifactorial; resulting from both intrinsic and extrinsic factors<sup>22</sup>. Also, the pain is commonly located around the acromion and lateral side of the upper shoulder and it is often exaggerated by overhead functional activities<sup>18</sup>. In the majority of cases, the pain negatively impacts sleep hygiene and daily activities; as a result, shoulder pain disorders become a chronic pain and socio-economic burden widely across the world<sup>23</sup>. The main concern of SAIS relates to functional loss and disability<sup>19</sup>.

### **Scope of challenges**

Over the years different hypotheses have been put forward to describe the pathogenesis of SAIS but, a clear explanation has not been established as of now<sup>18</sup>. Therefore, it remains a poorly understood entity whether the damage to the rotator cuff tendons causes the impingement (intrinsic mechanism) or the impingement causes the destruction of the rotator cuff tendons (extrinsic mechanism)<sup>24</sup>. The theories supporting the intrinsic mechanism are becoming more and more popular in the last few years<sup>25</sup>. These theories argue that the poor vascularity of the supraspinatus tendon insertion could be a significant factor in the pathogenesis of degenerative rotator cuff tears<sup>25</sup>. Conversely, over several decades the extrinsic theory supporters are demanding to correlate the SAIS

to different orientations of the scapula due to muscular imbalances (weakness-tightness) and increasing of thoracic spine curvature (kyphosis) as well as considering the morphology of acromion<sup>26</sup>. Moreover, SAIS terminology has been questioned among the healthcare professionals and believed as it is outdated<sup>25</sup>. However a simple search of the term brings up thousands of contemporary research articles and recent publications in many scientific databases. In addition to that, the SAIS is still categorised as a Medical Subject Heading (MeSH) in the National Library of Medicine. Therefore, a specific diagnosis of shoulder pain symptomatology is both difficult and controversial<sup>27</sup>.

According to the research studies<sup>20 28</sup> SAIS is a frequent root cause of shoulder pain. It has been suggested that successful prognosis related to shoulder pain and dysfunction is dependent on a precise diagnosis<sup>29</sup>. It is traditionally believed that effective medical history taking and comprehensive physical examination is a cornerstone to generate a potential hypothesis, subsequently successful clinical decision-making in medical practice<sup>30</sup>. Furthermore, this approach can help clinicians to get out of unnecessary advanced diagnostic tests exposure of the patients, thus potentially saving money, reducing time delay and avoid needless health risks<sup>31</sup>. Therefore, developing an accurate clinical decision based on the potential diagnostic utility of clinical examination would aid clinicians to design the early effective therapeutic interventions and consequently, it possibly leads successful clinical outcomes<sup>32</sup>. Unfortunately, at present this traditional clinical decision-making approach can be often challenged to make a precise differential diagnosis related to shoulder pain because over 186 clinical tests have been labelled and proposed for their application in the shoulder complex<sup>33</sup>. This leads to a challenging for clinicians to have a choice on appropriate clinical tests for differential diagnosis of shoulder pain<sup>10</sup>. Moreover, confusion arises by the description of the same clinical test with different names for example, the Empty Can test is also known as Jobe's test both suspected supraspinatus pathological involvement<sup>34</sup>. Besides, different criteria are applied to interpret the same clinical test for instance, either pain or weakness as a criterion to have a positive supraspinatus test<sup>35</sup>. However, there are other diagnostic utilities available such as magnetic resonance image, magnetic arthrography, diagnostic ultrasound, and intra-operative investigations to make a differential diagnosis of SAIS<sup>36</sup>. Nevertheless, these types of investigations are not affordable for clinicians<sup>37</sup>, who work in the primary care clinical setting; moreover it is not a cost-effective pathway<sup>38</sup>.

This review primary aim is to make a clear establishment through evidence-based practice to have the cost-effective and appraise diagnostic accuracy of commonly applied clinical tests for diagnosing SAIS. As a result,

it would aid clinicians to generate a potential hypothesis, subsequently design an appropriate therapeutic regimen to have successful prognostic outcomes related to the shoulder pain.

## METHODS

### Study Design

This systematic review followed the preferred reporting items for systematic reviews and meta-analysis (PRISMA) guidelines for conducting and reporting the study's findings. The study was exempt from the Human Ethics Committee review.

### Search Strategy

A literature search was conducted in June 2020 and included the following databases: Medline, EMBASE, Science Direct and the Cochrane Library. The search engines were searched using a combination of keywords and Medical Subject Headings of the National Library of Medicine designed to identify clinical tests, the diagnostic accuracy set, and the target condition. The following key words were included: "physical examination" OR "clinical examination" OR "routine diagnostic tests" OR "diagnostic tests, routine" AND "shoulder" OR "shoulder pain" OR "shoulder impingement syndrome" OR "bursitis" OR "tendinopathy" OR "rotator cuff" AND "sensitivity and specificity" OR "diagnosis." Checking references of the relevant articles and searching Google Scholar supplemented the search. Searches were limited to only English language.

| No | Search history                 | Results |
|----|--------------------------------|---------|
| 1  | Physical Examination/          | 215765  |
| 2  | Diagnostic Tests, Routine/     | 78480   |
| 3  | Shoulder/                      | 32305   |
| 4  | Shoulder Pain/                 | 16458   |
| 5  | Shoulder Impingement Syndrome/ | 2839    |
| 6  | Bursitis/                      | 4691    |
| 7  | Tendinopathy/                  | 5329    |
| 8  | Rotator Cuff/                  | 6356    |
| 9  | "Sensitivity and Specificity"/ | 363941  |
| 10 | Diagnosis/                     | 1333404 |

|    |                              |         |
|----|------------------------------|---------|
| 11 | 1 or 2                       | 291115  |
| 12 | 3 or 4 or 5 or 6 or 7 or 8   | 59940   |
| 13 | 9 or 10                      | 1677690 |
| 14 | 11 and 12 and 13             | 501     |
| 15 | limit 14 to English language | 491     |

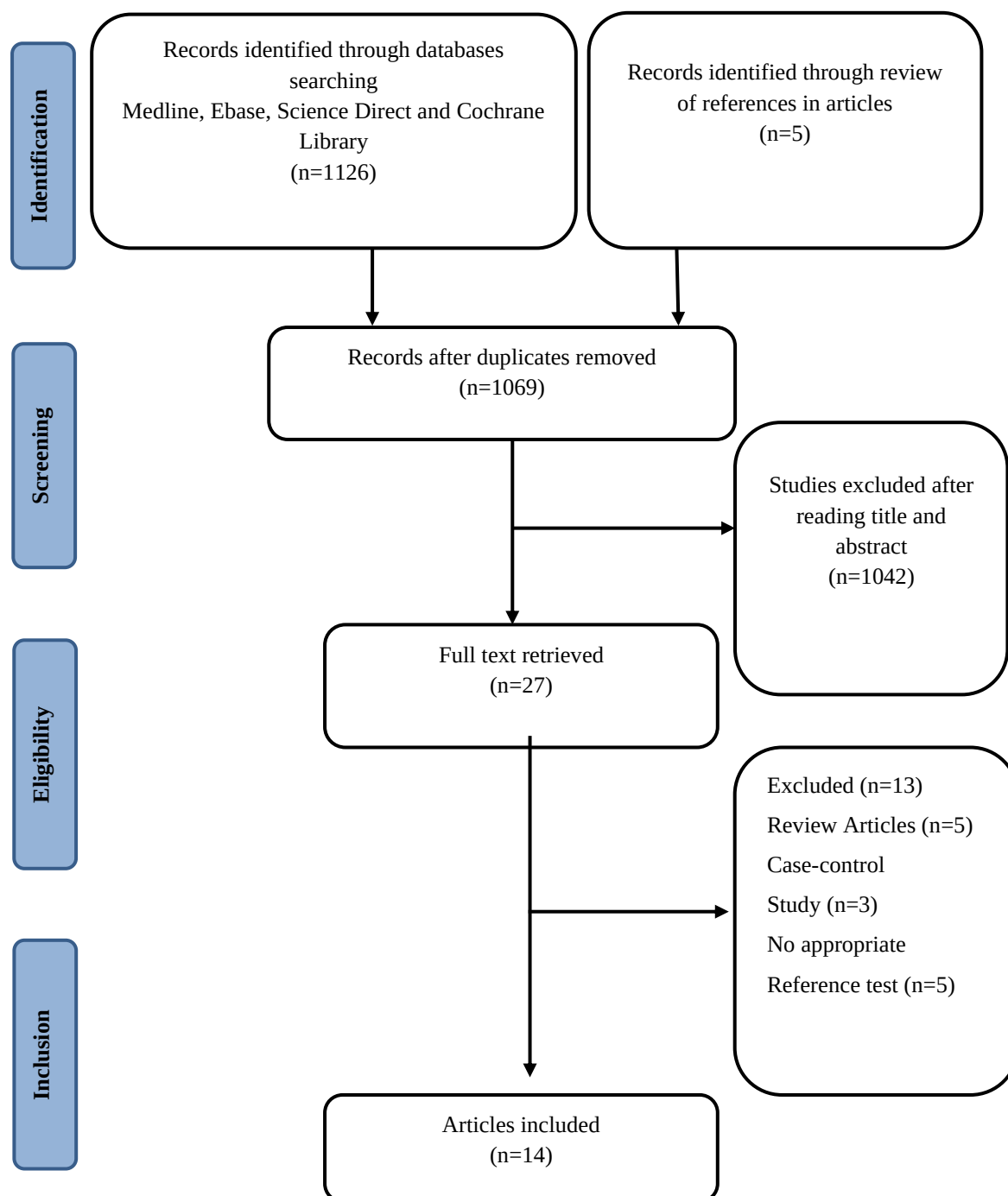
**Table 01:** EMBASE Search strategy

### Study Selection

Studies were included if they met the following inclusion criteria;

- 1 *Study Types:* Prospective or retrospective cohort studies
- 2 *Patient population:* Adult patients (age >18years) with painful shoulder
- 3 *Setting of care:* Inpatient and outpatient clinical settings
- 4 *Descriptive variables:* Any clinical test examined to diagnose the SAIS target condition in all three stages. Three stages and the relevant common clinical tests are described in table1.
- 5 *Reference test:* The following reference standards were considered acceptable for diagnosis of SAIS; using surgical diagnostic standard (arthroscopy/ intra-operative) and indirect imaging diagnostic methods (MRI/USS/CT arthrogram /anaesthetic) as the reference test.
- 6 *Diagnostic accuracy measures:* Each study was required to account or permit calculation of diagnostic values (sensitivity, specificity, positive and negative likelihood ratios) for all clinical tests.

Two reviewers (T.S, S.T) read the titles and/or abstracts of the identified references and eliminated irrelevant studies. Studies that were considered eligible for inclusion were read fully in duplicate, and both reviewers independently determined their suitability for inclusion to the study. Disagreements were managed by consensus.



**Figure 02:** PRISMA flow diagram of the studies

### Data Extraction

The number of sensitivity and specificity for each clinical test were extracted from each of the studies. In addition, both positive and negative likelihood ratios were tabulated either direct from available studies or calculated from the data provided the sensitivity and specificity findings. Discrepancies were resolved by discussion between the 2 reviewers (T.S and T.S). This review's primary investigator contacted the appropriate

corresponding study's author to gain further information when there was insufficient detail in an article to finalise the data extraction.

### **Quality Assessment**

After all relevant articles were attained; the quality of each included article was evaluated. The quality of the study was determined by examining that study's internal and external validity. This was assessed using the Quality Assessment of Diagnostic Accuracy Studies (QUADAS) tool<sup>39</sup>. It is a validated tool for the quality assessment of diagnostic accuracy studies<sup>40</sup>. The QUADAS tool has 14 questions, each involves individualised scoring as "yes", "no", or "unclear". In this review, two independent reviewers (T.S. and C.J.) applied the QUADAS tool to the included studies and dissimilarities in the assessment were fixed by discussion.

### **Data synthesis and Analysis**

This study has struggled to perform a meta-analysis because the majority of the included articles hadn't provided raw data (true positives, false positives, true negatives, and false negative) for constructing 2 by 2 table. Thus, this study has applied the methodology in previous study<sup>41</sup> of this nature to determine the accuracy of defined clinical tests for the each pathology. From included studies, each clinical test's sensitivity and specificity were extracted in addition to that both positive and negative likelihood ratios were tabulated either direct from available studies or calculated. Because, specificity is the probability of a positive test result in someone with the pathology, whereas sensitivity is the probability of a negative test result in someone without the pathology. The classification catalogue was followed in order to descriptively characterising degrees of this study's sensitivity and specificity<sup>42</sup>. It categorises as; low if 50% or less, low to moderate if between 51% and 64%, moderate if between 65% and 74%, moderate to high if between 75% and 84%, and high if 85% or greater. Positive likelihood ratios (+LR)  $> 1$  surge the post-test probability that the target condition is present. Negative likelihood ratios (-LR) closer to 0 decreases the probability of the target disorder with a negative finding, and the smaller the negative likelihood ratio, the greater the decrease in probability<sup>43</sup>. A positive finding with a test that has a  $LR+ > 10$  generates a large change in post-test probability, whereas a  $LR+$  of 5-10 moderately influences post-test probability. A negative finding with a test that has a  $LR- < 0.1$  generates a large shift in post-test probability, whereas a  $LR-$  of 0.1-0.2 moderately shifts the pre to post-test probability<sup>44</sup>.



## RESULTS

### Study Identification

A flow diagram of the search and selection of the study is presented in Figure 2. Records identified through databases searching on Medline, Embase, Science Direct and Cochrane Library in addition to that some records identified through review of references in articles and hand search on Google Scholar. After removal of duplicates, 1069 articles yielded. Among these 1069 considered articles, 1042 were excluded after reading title and abstract. All potential 27 full text articles were screened against the study inclusion criteria subsequently, 14 articles met the inclusion criteria and were selected for inclusion in the review. A description of the common clinical tests relevant to diagnose of all SAIS pathologies is described in Table 2.

| Study                          | No Patients | Mean Age                   | Clinical test                                                          | Reference Criterion     | Pathology | Publication details          |
|--------------------------------|-------------|----------------------------|------------------------------------------------------------------------|-------------------------|-----------|------------------------------|
| Takeda <sup>51</sup><br>2016   | 130         | 64.5<br>(39-77)            | Lift-off, belly press, bear-hug                                        | Arthroscopy             | SAIS 1-3  | Orthopaedic Japan.           |
| Sgroi <sup>56</sup><br>2019    | 112         | 57.3+ -<br>12.0            | Hornblower's sign, drop arm, ERLS, IRLS, Patte sign,                   | Arthroscopy             | SAIS 2-3  | Orthopaedic Germany          |
| Yoon <sup>52</sup><br>2013     | 312         | 57.1 + -<br>10.7           | Lift-off , IRLS, belly Press, bear-hug                                 | Arthroscopy/<br>Surgery | SAIS 1-3  | Orthopaedic South Korea      |
| Kappe <sup>53</sup><br>2018    | 106         | 57.3 +-<br>12.2<br>(32-80) | Lift-off , IRLS belly press, belly off , bear hug                      | Arthroscopy             | SAIS 1-3  | Orthopaedic Germany          |
| Sgroi <sup>58</sup><br>2018    | 115         | 57.3+ -<br>12.0            | Empty can, full can, drop arm<br>Scapular retraction                   | Arthroscopy             | SAIS 2-3  | Orthopaedic Germany          |
| Collin <sup>57</sup><br>2015   | 100         | 68                         | ERLS, Patte sign, drop arm                                             | CT<br>Arthrogram        | SAIS 1-3  | Shoulder clinic, France.     |
| Guosheng <sup>46</sup><br>2017 | 85          | 15-65                      | Belly press                                                            | MRI                     | SAIS 1-3  | Primary care China           |
| Lin <sup>54</sup><br>2015      | 235         | 51+ -<br>18.3<br>(26-76)   | Lift-off, belly press, IRLS, bear-hug, IRRRT                           | Arthroscopy             | SAIS 1-3  | Sports Medicine, China       |
| Liu <sup>47</sup><br>2016      | 200         | 46.8+ -<br>15.8<br>(14-77) | Hug-up, empty can full can, MNT<br>Hawkins-Kennedy                     | Arthroscopy             | SAIS 1-3  | Sports Medicine, China       |
| Sawalha <sup>45</sup><br>2015  | 47          | 58<br>(27-76)              | Subacromial grinding                                                   | Arthroscopy             | SAIS 2-3  | Orthopaedics UK              |
| Bartsch <sup>55</sup><br>2010  | 50          | 58 + -<br>11.6             | Lift-off , IRLS, belly press, belly-off sign                           | Arthroscopy             | SAIS 1-3  | MSK Clinic Germany           |
| Bak <sup>48</sup><br>2010      | 104         | 56<br>(39-75)              | Hawkins-Kennedy empty can, painful arc ERLS IRLS<br>Infraspinatus drop | MRI &<br>Injection      | SAIS 2-3  | Emergency Department Denmark |
| Fowler <sup>50</sup><br>2010   | 101         | 40.8+-<br>14.6             | Hawkins-Kennedy empty can, lift-off                                    | Arthroscopy             | SAIS 2-3  | Sports Medicine UK           |
|                                | 80          | 20-70                      | Neer's sign, full can,, empty can<br>Hawkins-Kennedy painful arc       | USS                     | SAIS 1-3  | Orthopaedics UK              |

**Table 02:** Characteristics of included studies

| Shoulder Pathology                         | Clinical Tests                                                                                           |
|--------------------------------------------|----------------------------------------------------------------------------------------------------------|
| SAIS                                       | Neer's sign, Hawkins-Kennedy test, Horizontal adduction test                                             |
| Supraspinatus tendinopathy                 | Empty can test, full can test, Drop arm test, Painful arc test,                                          |
| Infraspinatus and Teres minor tendinopathy | Resisted external rotation (infraspinatus test), External lag sign, Patte's test, Hornblower's sign      |
| Subscapularis tendinopathy                 | Bear-hug test, Belly press test/Napolean test, Belly-off sign, Lift-off test, Internal rotation lag sign |

**Table 03:** Description of the common clinical tests relevant to diagnose SAIS pathology

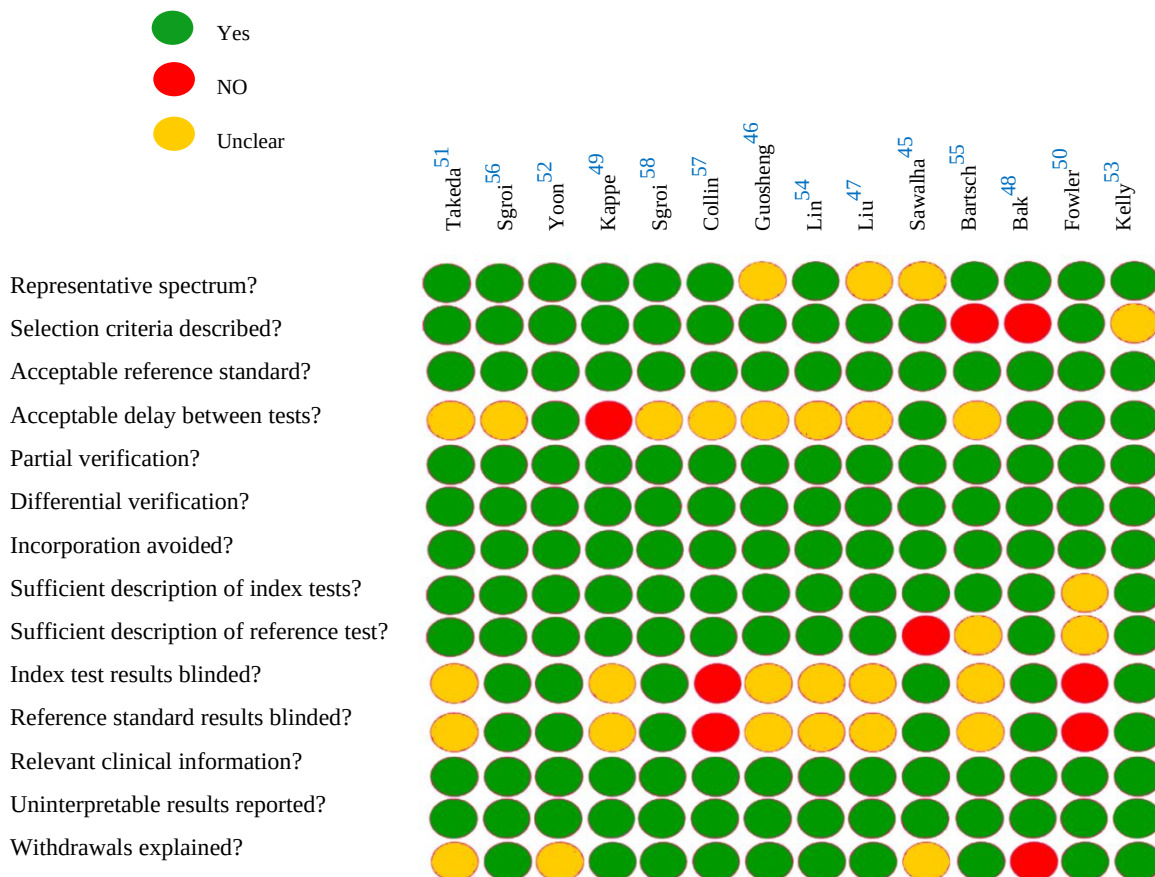
### Study Description

Table 3 refers to the characteristics of the included studies. In this review research finally 14 studies included a total of 1756 patients. All included studies were in English. The included studies sample range from 47 to 312 patients. The majority of included studies' study design was prospective and included studies' were carried out in various clinical setting such as sports, orthopaedic, musculoskeletal clinics, primary care and emergency department. However, higher proportion of the studies were set in speciality or tertiary care clinical setting and only 2 studies carried out reference tests that would apply to primary care clinical setting. Four studies were carried out in Germany, 3 in United Kingdom, 3 in China, 1 in Japan, 1 in Denmark, 1 in France, and 1 in South Korea. In this review, both surgical diagnosis (arthroscopy and intra-operative) and indirect imaging methods (MRI, CT arthrogram and diagnostic USS) were considered as the reference standard criterion. In the included 14 studies, twenty different clinical tests were examined to evaluate the diagnostic accuracy to define the pathology related to all three stages of SAIS. Among these, seventeen clinical tests were assessed against surgical diagnostic procedures, whereas twelve clinical tests were examined alongside the indirect imaging diagnostic methods.

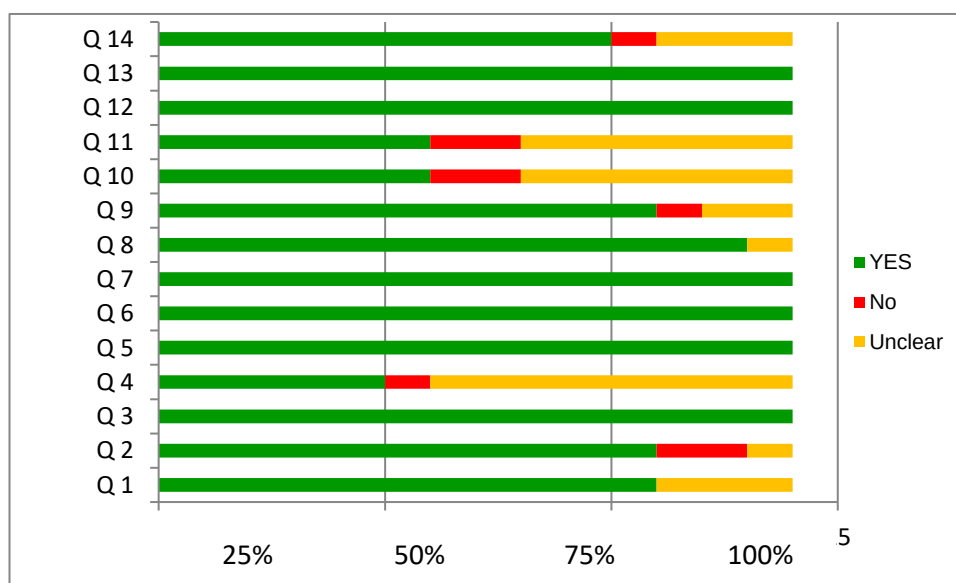
### Methodological Quality Assessment

The included each study's methodological quality score based on the 14 items of the QUADAS tool is presented in Figure 2. The overall summary of the included studies' methodological quality assessment by two independent reviewers (T.S & S.T) is illustrated in Figure 3. The overall quality ranges from moderate to good because, in the included 14 studies, 11 studies' overall methodological quality score is greater than 10 out of 14. In addition, in these individual 14 methodological quality measuring questions, the three questions' overall

answer is unclear. Among three questions, two questions evaluate whether the assessors were blinded to the outcome between the index tests and reference standard criterion, whereas one question assesses about the time delay between the clinical test and the reference test.



**Figure 03:** Individual study's score against the QUADAS



**Figure 04:** Methodological quality of included studies

### **Diagnostic value of clinical tests**

Table 2 describes the 20 common clinical tests included in 14 diagnostic accuracy studies in comparing either surgical or indirect diagnostic imaging reference standard for the diagnosis of SAIS and associated with rotator cuff pathologies. These findings were clustered by two main target conditions such as subacromial impingement and rotator cuff tendinopathy including supraspinatus, subscapularis and infraspinatus-teres minor because of the involvedness of a quite large number (20) of clinical tests.

### **External impingement**

In this included studies, 4 clinical tests' such as Neer's, Hawkins-Kennedy, subacromial grinding and modified Neer test accuracy were evaluated for diagnosing the SAIS. The subacromial grinding test was examined in a single surgical reference criterion study<sup>45</sup> total of 50 shoulders. The sensitivity, specificity, and +LR (diagnostic utility) values ranged from 73%, 91% and 9.5 respectively. The modified Neer's test was inspected in an indirect imaging reference criterion study<sup>46</sup> total of 85 patients. The diagnostic utility values ranged from 85%, 96% and 19.1 correspondingly. However, Neer's and Hawkins-Kennedy tests' diagnostic accuracy was examined in both surgical and indirect imaging reference standard studies. The Neer's test diagnostic values in a single surgical reference standard study<sup>47</sup> total of 200 patients ranged from 62.7%, 89.4% and 5.9. In contrast, it was explored in 3 indirect imaging studies<sup>46, 48, 49</sup> total 269 painful shoulders and its diagnostic utility values ranged from 45.5-90.2%, 17.4-50% and 0.6-1.8. The Hawkins-Kennedy test diagnostic values in 2 surgical reference standard studies<sup>47, 50</sup> total 301 patients ranged from 35.9-57.6%, 72.1-87.2% and 2.1-2.8. In contrast, it was investigated in 2 indirect imaging studies<sup>48, 49</sup> total 184 shoulders and its diagnostic utility values ranged from 55.6-88.9%, 13-40.9% and 0.7-1.5.

### **Rotator cuff tendinopathy**

#### ***Clinical tests for subscapularis***

Five clinical tests such as lift-off, belly-press, belly-off, bear-hug test and IRLS evaluated the subscapularis's pathological association for SAIS. However, except IRLS, other 4 clinical tests were investigated only against the surgical reference standard. The lift-off is in 6 studies <sup>49,50,51,52,53,54</sup> total 934 painful shoulders. The diagnostic utility values ranged from 18.8-65.2%, 68.5-98% and 1.9-17.5 respectively. The belly-press test is in 5 studies<sup>49,51,52,53,54</sup> total 833 patients and diagnostic utility values range are in the following way 34-80%, 79.7-96% and 3.2-8.5. The bear hug test is in 4 studies<sup>52,53,54</sup> total 783 patients. The diagnostic utility values are ranging from 18.8-73.7%, 79.9-97.4% and 0.98-28.4 in that order. The belly-off test is in 2 studies<sup>53,55</sup> total 156 patients and its diagnostic utility values are ranging from 31-86%, 91-97% and 9.6-10.3 correspondingly,

whereas the IRLS was investigated in both surgical and indirect imaging reference standards. In surgical reference standard, IRLS was in 4 studies<sup>52,53,54,55</sup> total 703 patients and its diagnostic utility values sensitivity, specificity and +LR range from 31.6-71%, 60-92.5% and 1.8-4.6 respectively in contrast in indirect imaging criterion standard, IRLS was in one study<sup>48</sup> total 104 patients its utility ranged from 31%, 87% and 2.4.

### ***Clinical tests for supraspinatus***

Six clinical tests full can, empty can, drop arm, 0 abduction, hug-up and painful arc were explored in this review for supraspinatus associated with SAIS. The full can, empty can, drop arm and 0° abduction were investigated in both surgical and indirect imaging reference standards. In surgical reference criterion, empty can test in 3 studies<sup>47,50,56</sup> total 416 patients its diagnostic values range 66.7-91%, 41-74.5% & 1.1-3.3, full can test in 2 studies<sup>47,56</sup> 315 patients its diagnostic values are 78.4-79%, 69-80.9% & 2.6-4.1, drop arm test in 1 study<sup>56</sup>, 115 patients its diagnostic values 24%, 77% & 1.1 and 0 abduction test in 1 study<sup>56</sup> 115 patients its diagnostic values are 64.5%, 54% & 1.4. In contrast, indirect imaging reference standard empty can test in 2 studies<sup>48,49</sup> total 184 patients its diagnostic values from 64.3-76%, 12.5-39% & 0.8-1.3, full can test in 1 study<sup>49</sup> 80 patients its diagnostic values 66.7%, 25.5% & 1, drop arm test in 2 studies<sup>48,57</sup> 204 patients its diagnostic values 41-87%, 83-88% & 2.4-7.3 and 0 abduction test in 1 study<sup>49</sup> 80 patients its diagnostic values 70.9%, 31.2% & 1.1. The hug-up test was investigated in a single surgical reference criterion study<sup>54</sup> 200 patients its diagnostic values 94.1%, 76.6% & 4, while painful arch in 2 indirect imaging reference standard studies<sup>48,49</sup> 184 patients its diagnostic values ranged 55-96%, 4-44.4% & 0.7-1.3.

### ***Clinical tests for infraspinatus and Teres minor***

Five clinical tests such as ERLS, Patte's sign, Hornblower's sign, infraspinatus drop sign and scapular retraction test evaluated the infraspinatus and teres minor's pathological association for SAIS. The ERLS and Patte's sign were investigated in both surgical and indirect imaging reference standards. In surgical reference standard, ERLS was in one study<sup>58</sup> 115 patients its diagnostic utility ranges from 21.5%, 92% and 2.6 respectively in contrast in indirect imaging criterion standard, ERLS was in 3 studies<sup>48,49,57</sup> total 284 patients and its diagnostic utility values range from 45-100%, 18.2-92% and 0.9-12.5. Whereas, Patte's sign in a single surgical reference criterion study<sup>58</sup> total 115 shoulders and its diagnostic utility values range 77.5%, 33% and 1.2, in contrast in indirect imaging criterion standard, Patte's sign was in a single study<sup>57</sup> total 100 patients and its diagnostic utility values range from 93%, 72% and 3.3. The Hornblower's sign and scapular retraction test were investigated in a single surgical reference criterion study<sup>58</sup> 115 shoulders its diagnostic values ranges from 19-

54%, 63-93% & 1.5-3.6, whereas infraspinatus drop sign in a single indirect imaging reference standard study<sup>48</sup> 104 sample its diagnostic values range 45%, 70% and 1.5 respectively.

## DISCUSSION

This study goal is to investigate the diagnostic accuracy of clinical tests for involving differential diagnosis of SAIS. This review assessed studies that examined the clinical test's diagnostic utility when compared to the reference criterion either surgical or indirect imaging diagnostic reference standard.

### Summary of principal findings

This review included 14 studies in total 1756 shoulders and considered a number of standard, modified and novel clinical tests for making a differential diagnosis of SAIS. In this review, the overall methodological quality is high. The 10 included studies were examined against the surgical reference criterion, which is called "gold standard", whereas 4 studies were carried out against indirect imaging diagnostic reference standard. A number of clinical tests (n=17) diagnostic accuracy was examined to rotator cuff pathology associated with SAIS and only 3 clinical tests found that had been directly assessed for diagnosing SAIS. Furthermore, the majority of included studies investigated for all 3 stages of SAIS pathology from subacromial bursitis, partial to full-thickness of rotator cuffs.

This narrative descriptive review suggests based on their positive likelihood<sup>44</sup> subacromial grinding and modified Neer clinical tests for "ruling in" SAIS because these 2 clinical tests have + LR > 10 it is relatively high diagnostic utility<sup>44</sup>. However, the subacromial grinding test (+LR-) was evaluated against the surgical reference standard and modified Neer's test (+LR-) was investigated in an indirect imaging reference criterion. The lift-off (17.5), bear-hug (28.4) and belly-off (10.3) tests were assessed against the surgical reference standard and these tests + LR in the maximal category. Therefore, this indicates that patients are more likely to have subscapularis associated SAIS when these 3 clinical tests are positive. To rule in the supraspinatus pathology associated with SAIS can be examined by drop arm test because its +LR (7.25) in the moderate classification; however it was assessed against indirect imaging standard. Whereas, hug-up, full can and empty can tests diagnostic accuracy were investigated against the surgical reference standard, but their +LR between 2 to 5 in the minimal classification. The ERLS test has higher (12.5) +LR and suggests for ruling the infraspinatus associated SAIS when this test is positive. However, it was assessed against the indirect imaging reference standard whereas, Hornblower's sign test diagnostic accuracy was examined against the surgical reference standard, but their +LR (6.6) in the moderate classification.

### Study Limitations

This review has limitations. Firstly, the majority of the included articles hadn't provided raw data (true positives, false positives, true negatives, and false negative) for constructing 2 by 2 table therefore; this review was not performed in the meta-analysis. Secondly, this review primary intention was to investigate the diagnostic accuracy of clinical tests in primary care clinical setting as shoulder pain are the third most common complaint of musculoskeletal disorders in primary care clinical settings<sup>10</sup>, where the majority of shoulder pain is conservatively managed by general practitioners and physiotherapists<sup>6</sup>. Unfortunately, in this review only 2 studies examined in primary care clinics and the remaining 12 studies explored the diagnostic accuracy of SAIS and rotator cuff associated pathological involvement clinical tests in specialist clinics. In this setting, the clinical examination is performed by various clinicians including medical surgeons and rheumatologists. This review included studies' overall quality range was from moderate to good because in the included 14 studies, 11 studies' overall methodological quality score was greater than 10 out of 14. However, the primary concerns with methodological quality relate to the time delay between the clinical test and the reference test, and it is unclear in many studies whether the assessors were blinded to the outcome of the index and reference tests. The previous systematic review<sup>59</sup> on similar topic also has limitations in these both aspects.

There is a need for future prospective cohort studies in primary care settings, get rid of time delay and ensure double blinded process between the clinical test and reference tests to examine the diagnostic accuracy of these clinical tests.

### Current context and future research recommendations

The international guidelines recommend that clinical tests such as the Neer's sign, Hawkins-Kennedy test, and drop arm test may be helpful as a part of the clinical examination. In addition to that, a previous systematic review's meta-analysis on the similar topic concludes that the lift-off test has the highest diagnostic utility for ruling in SAIS when the test is positive. In this review, there appears to be a diagnostic utility of subacromial grinding test, lift-off, bear-hug and belly-off tests that provides evidence to rule in SAIS when the tests are positive. In order to confirm the reliability, validity and diagnostic accuracy of these clinical tests further studies are essential based on larger sample sizes, a reduced time delay between the index and reference tests studies and minimising risks of bias.



## CONCLUSION

The SAIS has high prevalence pathology among shoulder disorders however; it can be often challenging clinicians to have an accurate diagnosis on it. This is an updated study of previous systematic reviews related to evaluating the accuracy of clinical tests for diagnosing SAIS. Making a precise differential diagnosis will ultimately ensure the appropriate therapeutic interventions, subsequently successful prognosis on SAIS patient thus, the diagnostic utility of the subacromial grinding test, lift-off, bear-hug and belly-off tests clinical tests need to be considered in the context of the clinical practice of the overall patient assessment.

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