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SYSTEMATIC REVIEW

The diagnostic value of physical examination tests in adhesive capsulitis: a systematic review

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ABSTRACT

INTRODUCTION: Adhesive capsulitis, a condition marked by pain and stiffness of the shoulder, can have a frustrating clinical course for patients and health care professionals. Despite huge research interest, a universally accepted and used definition of clinical criteria for the diagnosis of adhesive capsulitis is currently still lacking. This systematic review aimed to identify diagnostic values for clinical examinations tests used in the diagnosis of adhesive capsulitis.

EVIDENCE ACQUISITION: A total of 5 electronic databases (PubMed, Web of Science, Embase, Cochrane Central Register of Controlled Trials [CENTRAL] and PEDro) were searched for relevant studies from 2002 until October 2022 using the terms: "adhesive capsulitis AND diagnosis" and "frozen shoulder AND diagnosis." The Downs and Black Checklist (modified) was used to assess the risk of bias. The study protocol was prospectively registered at the International prospective register of systematic reviews (PROSPERO, CRD42022365993).

EVIDENCE SYNTHESIS: The initial database search identified 1799 studies, of which 9 (0.50%) were eventually included in the systematic review. Non-intrusive shoulder range of motion measurements in patients with adhesive capsulitis using the Kinect for Windows (Microsoft, Redmond, WA, USA) showed high correlation with clinical range of motion measurement. Two specific clinical tests, the affected-unaffected shoulder approach of the Coracoid Pain Test and the Distension Test in Passive External Rotation, were identified and presented excellent sensibility and specificity in the diagnosis of adhesive capsulitis, in their original study. Comparison between clinical tests was not possible due to the heterogeneity in clinical tools.

CONCLUSIONS: This systematic review identified several physical examination tests developed for the diagnosis of adhesive capsulitis but could not compare them nor advance a set of clinical diagnostic tests that are scientifically validated. Further research is warranted to obtain validation of clinical diagnosis tools for adhesive capsulitis.

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KEY WORDS: Diagnosis; Diagnostic tests, routine; Shoulder.

Introduction

Adhesive capsulitis (AC) of the shoulder is a clinical entity in which patients have a painful shoulder stiffness. The clinical course of this condition generally is protracted and complicated, both for patients and health care professionals.[1-6] Since 2002, more than 3000 articles have been published referring to AC.[7] Many new insights into its natural history, pathophysiology and available treatments have emerged, but a lot of questions remain to be

answered.[2, 5, 8-10] It is remarkable that since the first description of AC by Codman[11] in 1934 the patient's clinical examination has remained the cornerstone of diagnosis, while a universally accepted definition (or an operational agreement) on the clinical criteria of AC diagnosis is still lacking.[3, 9, 12] There even is some controversy on how the condition should be named: some authors[13, 14] distinguish between AC and frozen shoulder (FS), whereas most publications use both terms interchangeably.[1, 3, 8, 15, 16]

Adhesive capsulitis can be primary (idiopathic) or secondary to a pre-existing identified surgical or medical issue.[2, 3, 17] The prevalence of primary AC in the general population has been described between 2 and 5%[8, 14] and is much higher in some populations, such as diabetes patients or Parkinson's disease.[18-21] The natural history of AC often has been described as occurring in three consecutives phases: a "freezing" phase with acute pain and stiffness, followed by a "frozen" phase with established stiffness and lower pain finals, to finally reach a third "thawing" phase with gradual return of range of motion (ROM).[22] In recent years, researchers have questioned this chronological framework, making the need for a clear definition of this condition and its possible clinical manifestations even more relevant.[12, 15, 23]

Several medical societies have published consensus statements on the diagnosis of AC, based on surveys submitted to their members or through open reviews.[3, 17, 24, 25] Proposed definitions differ between medical societies with regards to the presence (or not) of pain, the duration of symptoms, the need for medical imaging and the possibly self-limiting time course.[2, 12, 13, 26] As such, 82% of the surveyed clinician members of the American Shoulder and Elbow Surgeons agreed with the definition of frozen shoulder (FS) as proposed by Zuckerman *et al.*[17] in 2011: "FS is a condition characterized by functional restriction of both active and passive shoulder motion for which radiographs of the glenohumeral joint are essentially unremarkable except for the possible presence of osteopenia or calcific tendonitis." Notably, 84% of these surveyed respondents agreed with the statement that finding a consensus definition and classification of FS is a worthwhile endeavor.[17] In South-Korea, 85% of the 95 shoulder specialist participating in a survey (strongly) agreed with the following definition: " AC is a painful self-limiting functional restriction in both passive and active shoulder motion, lasting more than a month for which radiographic findings are unremarkable."[3] Based on an open review (N. articles =1559), Abrassart *et al.*[2] suggested an updated version for defining primary FS as a "condition characterized by often severe shoulder pain and functional restriction of both active and passive shoulder motion in which radiographs of the glenohumeral joint are essentially unremarkable." In agreement with these authors' statements,[1-3, 17] we believe that the lack of a clear-cut clinical definition for AC negatively influences the quality of future research on this topic. It is worth noting that despite the absence of consensus on how to clinically diagnose AC, an increasing amount of publications (including systematic reviews) describe the diagnostic value of imaging studies in AC.[26-30] For an overview of diagnostic imaging of AC, we refer to the recent systematic reviews on ultrasound and MRI.[26, 28]

Nevertheless, due to the importance of clinical examinations in clinical practice, we strive to provide further insights into the value of clinical examinations to diagnose AC. Therefore, the aim of the present systematic review is to investigate the diagnostic value of physical examination tests for AC.

Evidence acquisition

Protocol and registration

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Review and Meta-Analysis Guidelines (PRISMA).[31] The protocol was prospectively registered in the PROSPERO database (CRD42022365993). Ethics committee or institutional review board approval were not required.

Literature search strategy

A structured search was performed, and potential studies were identified in the following databases (and trials registers): PubMed, Web of Science, Embase, Cochrane Central Register of Controlled Trials (CENTRAL) and PEDro. Database search was conducted with the following MeSH terms: "adhesive capsulitis AND diagnosis" and "frozen shoulder AND diagnosis" for articles between January 1, 2002, and October 14, 2022. The "human" filter was used in the PubMed search.

Eligibility criteria

Publications were eligible for inclusion when there was: 1) diagnosis of adhesive capsulitis or frozen shoulder based on clinical findings; and 2) evaluation of the measurements properties (accuracy) of the diagnostic tool. We restricted our selection to prospective or retrospective clinical trials on adult humans (18 yrs or older), published from January 1, 2002, and October 14, 2022, and providing an English abstract and text. The description of the criteria for the

clinical diagnosis of AC had to be stated in full text in the methods section of the considered manuscripts. Our exclusion criteria were: studies investigating neurological, traumatic or postsurgical patients, review articles, studies on less than 10 subjects or imaging studies. Imaging studies were excluded, since the current consensus remains that diagnosis of AC is a clinical diagnosis.[2, 3, 17]

Study selection and data extraction

Studies identified through the database search were uploaded in the web application Rayyan[32] to facilitate duplicates extraction, review of titles and abstracts. After elimination of duplicates, two independent reviewers screened (MS and SH) titles and abstracts to identify eligible publications. Disagreements were solved by consensus, with the involvement, if necessary, of a third review author (JN). Data extraction was performed by one author (MS) while a second author (SH) carried out a data check for all accuracy parameters. This has been shown to produce a methodologically sound procedure.[33]

Risk of bias assessment

Risk of bias of individual studies was assessed independently by two reviewers (MS and SH) using the modified Downs & Black (D&B) Tool. The D&B Checklist is a recommended tool for valid assessment of the methodological quality of both randomized and non-randomized health care intervention studies.[34, 35] The D&B Tool consists of 27 items categorized into 4 sections: reporting (10 items), external validity (3 items), internal validity (13 items: bias -7 and confounding -6) and power (1 item). In the modified D&B Tool, only the last item is modified, with the Power item question giving 1 or 0 points whether or not a power analysis was performed.[36] Disagreements between authors were discussed and subsequently solved. The D&B scale has shown face and content validity, criterion validity and reproducibility in the fields of physical medicine and rehabilitation.[35, 37] In accordance with previous publications, studies can be classified as excellent (26-28), good (20-25), fair (15-19), and poor (≤14) quality.[38, 39]

Evidence synthesis

Study selection

The search of the five databases: PubMed, Web of Science, Embase, Cochrane Central Register of Controlled Trials (CENTRAL) and PEDro; identified unique 1799 citations. Details of the reviewing process can be found in the PRISMA diagram (Figure 1). Duplicates were removed and citations were screened for the inclusion criteria on the basis of title and abstract. This yielded 39 full-text manuscripts that were further screened for inclusion criteria. Reference lists of these full-text manuscripts were checked manually for relevant citations, and this yielded 4 additional full-text manuscripts. After screening the 43 full-texts, a total of thirty-five manuscripts were rejected for not meeting the inclusion criteria. Nine publications met the inclusion criteria and were included in this systematic review.

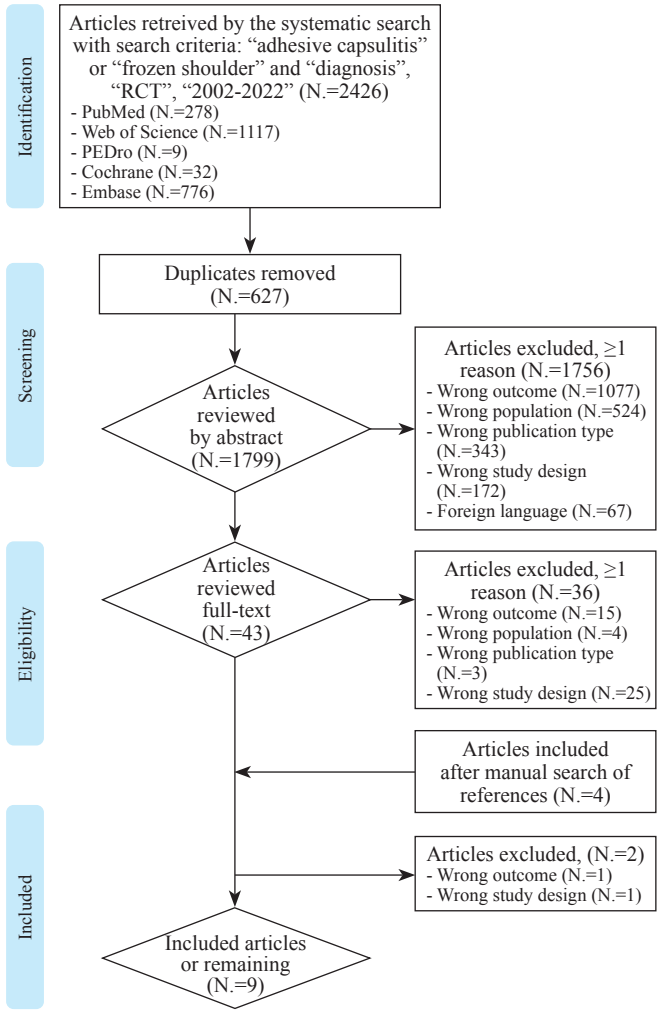

Figure 1.—PRISMA flow diagram of study selection process.
The diagram is based on Moher, PLosMed 2009 PRISMA Group.

Characteristics and main findings of included studies

Supplementary Digital Material 1 (Supplementary Table I)[40-48] summarizes the characteristics and main findings

of the 9 included publications. Only two publications described the same outcome measure.[40, 41] Six articles investigated a physical examination test.[40-45] One article examined a set of clinical identifiers.[46] Two articles compared the clinical examination of AC, either to the ROM measured with a Kinect (Microsoft, Redmond, WA, USA) or to the volume of the gleno-humeral capsule.[47, 48] Sample sizes ranged from 12 to 155 patients with AC.[42, 47] With this limited evidence, we decided that it was not useful to pool the data of the publications.

Methodological quality of studies

The quality of the nine included articles was scored with the modified D&B Tool. The scores of each study are shown in Figure 2. The average score of the included publication was 17.00 (±standard deviation of 2.92) which can be considered as "fair" methodological quality.[38, 39] Two studies, by Gumina *et al.*[42] and Mertens *et al.*,[41] were rated as "good" quality on the modified D&B Checklist.

Summary of evidence

In the study by Carbone *et al.*,[40] the diagnostic values for the Coracoid Pain Test (CPT) in patients with AC compared to healthy controls were very high: sensitivity 0.99 (0.99-1.00); specificity 0.98 (0.97-0.99); PPV 0.99 (0.98-1.00); NPV 0.99 (0.98-1.00). Using an instrument-assisted CPT, to increase the reliability of the applied pressure to the different areas, Mertens *et al.*[41] were unable to reproduce these high values. This latter study did however find an excellent specificity and positive likelihood ratio when using an affected-unaffected shoulder approach instead of a between-group comparison. The Distension Test in Passive External Rotation (DTPER) in the study by Noboa *et al.*[43] also showed excellent characteristics: sensitivity 1.00 (0.92-1.00); specificity 0.90 (0.82-0.95); PPV 0.62; likelihood ratio of 10.22 (5.5 -19.1). In all three studies (Carbone *et al.*[40] Mertens *et al.*[41] Noboa *et al.*[43]), the diagnosis of AC was based on pain symptomatology, clinical examination (limitation of abduction and external rotation) and unremarkable radiographic examinations.

In their prospective, non-controlled, cross-over trial, James-Belin *et al.*[48] showed, in patients in which AC had been confirmed by GH capsule volume of less than 12 mL that decreasing ranges of passive gleno-humeral (GH) abduction produced increasingly positive predictive values (PPV). The authors suggested that their study was underpowered (N.=38) to detect correlations between other passive ROM measures and capsular volume.

The results of the study of Lee *et al.* indicated that the Kinect for Windows ([Microsoft] a markerless three-dimensional depth camera able to recognize and process the coordinates of predefined body segments) can be used to measure reliably and non-intrusively shoulder ROM with an excellent agreement with standard goniometric measurements: ICCs between kROMs and aROMS (flex, 0.864; abd, 0.932; extrot, 0.925 and pROMs: flex, 0.906; abd, 0.942; extrot 0.911). Furthermore, using ROC curves to determine optimal cut-offs, this study provided a set of

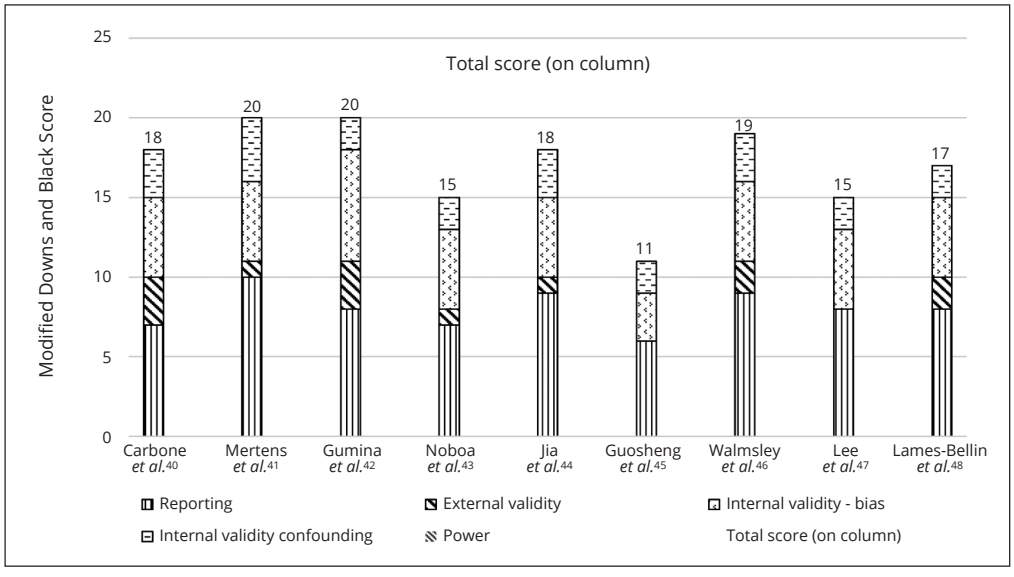

Figure 2.—Methodological quality of score distribution based on the modified Downs and Black Score.
Possible range of scores 0-28.

Kinect values (flexion <158.3°, abduction <159.1°, external rotation <59.1°) which diagnosed AC in all patients correctly and identified each of the healthy controls correctly.[47]

The Shoulder Shrug Sign[44] and the Arm Squeeze Test[42] presented quite high sensitivity values (0.95% resp. 0.96), though these studies were not specifically designed for diagnosing AC. The specificity of the Arm Squeeze test was high (0.98) when AC was compared to neck pain. This study did not compare AC to other types of shoulder disease. The specificity of the Shoulder Shrug Sign was low (0.50) compared to the other evaluated clinical tests.

The study by Walmsley *et al.*[46] stands out for not validating a single physical examination test but instead validating a previously identified set of clinical identifiers for the early stage of primary AC.[49] This set of clinical identifiers includes anamnestic pain criteria, global active or passive loss of motion and provoked pain at end of range in all directions. None of the clinical identifiers could be validated, though most of them are commonly used in clinical practice and recognized by literature.[50-52]

Discussion

This systematic review focused on the diagnostic value of physical examination to diagnose AC. A total number of 2426 publications, yielding 1799 unique citations, on AC was systematically reviewed for relevance and quality with regards to the clinical diagnosis of AC. This procedure yielded 9 publications corresponding to the inclusion criteria of the systematic review. These articles described the diagnostic value of clinical identifiers and tests for discriminating patients with AC from patients with pain due to other causes, or from healthy subjects. Overall, the methodological quality of the included publications, as assessed with the modified Downs & Black checklist, was fair.

The datasets of the 9 included publications could not be directly compared or aggregated for the following reasons: 1) only two publications investigated the same physical examination test[40, 41] and none of the other clinical assessment tools[42-44, 46-48] was used in more than one study in AC; and 2) even when using the same physical examination test (Coracoid Pain Test), a large difference in specificity was found in function of the way sampled data were analyzed (low specificity with between-group comparisons *vs.* high specificity with a "within-patient" or affected-unaffected approach). Thus, it was not possible to distinguish a single clinical diagnostic test showing the best diagnostic accuracy.

Up to now, literature remains unconclusive on to how to name, classify and diagnose AC.[1, 2, 5, 12, 13] In this article, we used the term adhesive capsulitis, unless we refer to a definition using the term frozen shoulder (FS)[2, 17] and we will leave the discussion around the naming of the condition outside the scope of this article. Despite inconsistencies in defining the condition, the description of the symptoms remains quite consistent: progressive insidious sleep-disturbing pain and stiffness, thickening of ligaments or capsule, reduced articular volume and some form of healing-associated biological evolution.[2-4, 9] The lack of a universal set of criteria to diagnose AC complicates the interpretation of many, if not all, published manuscripts on this condition due to a recruitment bias. Different medical societies have proposed own definitions for AC (or FS). No country-based or continent-based consensus has been achieved, using adequate methodologies. Robust methods for creating a consensus-based definition of AC could be: an expert consensus workshop using the Delphi method, such as done previously for Complex Regional Pain Syndrome in 2019;[53] or by conducting large scale web-based surveys of physicians from different specialties, regions and countries who are recognized shoulder experts. Walsmley *et al.*[49] used the Delphi method in 2009 to establish a consensus on clinical identifiers for stage 1 of AC. However, the two surveys aimed at identifying a consensus on the definition, diagnosis and treatment of AC were collected by gathering the opinions of only 95 Korean[3] and 190 American shoulder surgeons.[17] Consensus-based definitions need to be anchored in scientific evidence such as provided by systematic reviews. The present systematic review shows that such scientific evidence is not available at present. This further questions the results of therapeutic trials and the validity of diagnostic imaging criteria for AC. Due to a recruitment bias, previous studies may include patients with or without "true" AC, just as if low back pain was diagnosed solely based on MRI images of a herniated disk. Patients with AC are diagnosed and treated by a variety of specialists such as orthopedic surgeons, physiatrists, rheumatologists, or endocrinologists. The important discrepancy between the definitions of AC (including or not the presence of pain) surveyed by Zuckerman *et al.*[17] and by Cho *et al.*[3] indicates that opinions of shoulder specialists from different specialties and geographical regions should be searched for before launching a trial for consensus.

Recommendations for future research

Future research is needed to comprehensively evaluate the accuracy of diagnostic properties of existing clinical examinations tests and combinations of these tests. Studies should clearly indicate the diagnostic criteria that were used to define AC and how they were applied regarding du-

ration of symptoms, magnitude of ROM loss, assessment of total ROM *versus* gleno-humeral ROM and pain evaluation (VAS or NPR scale). Creating an evidence-based consensus on the criteria used to diagnose AC is necessary for the quality of future research and clinical work-up.

Limitations of the study

First, the number of studies retrieved in this review was low (N.=9). Though some articles reported high sensitivity and specificity values for a specific diagnostic test, none of these results were reproduced in further publications. In 2008, Hegedus *et al.* noted that many physical examination tests of the shoulder have shown great promise in the original study and proved to be far less valuable in subsequent trials.[54] With this limitation taken into account, results of the present review suggest that the DTPER and instrument-assisted affected-unaffected shoulder approach of the CPT may be of interest for further research. Further studies could investigate the reproducibility of their diagnostic value and/or include them in a set of physical examinations tests and clinical identifiers.

Second, the inclusion criteria for AC patients and controls differed vastly among the 9 studies. Therefore, any evidence may not be extrapolated to the entire population of patients with AC or cannot be considered representative of a particular subtype of AC patients.

Finally, only one study (by Lee *et al.*[47]) reported the determination of optimal cut-offs using ROC curves. This method could be of particular interest to establish thresholds for shoulder ROM limitations as well as for other clinical tests. The other publications in this systematic review reported arbitrarily chosen cut-off values to categorize patients. As an example, arbitrarily-set differences in provoked pain intensity (VAS>3/10) were used for the DTPER, the CPT and arm squeeze tests.[40, 42]

Conclusions

Our systematic review identified several physical examination tests developed for the diagnosis of adhesive capsulitis but was unable to conduct a meta-analysis due to the heterogeneity in examination tests. Diagnostic criteria of AC used in the current literature remain heterogeneous. Our findings are unfortunately insufficient to develop a clinical diagnostic set of AC, combining a scientifically accepted definition of symptoms and signs. Further research is warranted to obtain more precise clinical diagnosis tools for AC, probably using a combination of clinical identifiers and a set of physical examinations tests.

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Conflicts of interest
The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

Authors' contributions
Marc Schiltz, Lisa Goudman, Maarten Moens, Jo Nijs and Samar M. Hatem contributed equally to the manuscript. They also have given substantial contributions to study design, data acquisition, analysis and interpretation, and manuscript writing. All authors read and approved the final version of the manuscript.

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Supplementary data
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