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ASSESSMENT AND DIAGNOSIS OF NON-TRAUMATIC SHOULDER INSTABILITY: A SCOPING REVIEW

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AVANT-PROPOS

Ce mémoire s'inscrit dans un projet de synthèse et d'actualisation des connaissances concernant l'épaule instable non-traumatique. L'objectif est de guider les cliniciens dans le diagnostic et l'évaluation de cette population, tout en fournissant une orientation pour les futures recherches sur ce sujet.

Dans un premier temps, cette revue de portée vise à rassembler l'ensemble des éléments existants pour diagnostiquer et évaluer les épaules instables non-traumatiques.

Par la suite, une méthodologie de consensus sera mise en place afin d'identifier de nouveaux éléments d'évaluation qui n'auraient pas été identifiées lors de la première étape, puis d'établir un consensus sur les éléments à recommander pour l'évaluation.

Pour ce faire, nous travaillons en collaboration avec Anju Jaggi, une physiothérapeute spécialiste de l'épaule au Royal National Orthopaedic Hospital de Stanmore, au Royaume-Uni. Au cours de ces 15 dernières années, elle a publié de nombreux articles sur l'instabilité de l'épaule, notamment sur l'instabilité non-traumatique.

En raison de notre collaboration avec Anju, l'ensemble du projet est conduit en anglais, y compris ce mémoire dont l'ambition est de le soumettre pour publication.

RÉSUMÉ ET MOTS CLÉS

Contexte : L'instabilité non-traumatique de l'épaule (NTSI) est une forme d'instabilité d'épaule à ne pas négliger. En raison de la variabilité des systèmes de classification ainsi que des nombreuses formes cliniques, le diagnostic et l'évaluation de cette NTSI représentent un défi pour les cliniciens. Il n'existe pas, à ce jour, de consensus quant aux critères et outils diagnostiques afin de les guider. Par ailleurs, l'incidence précise de cette dysfonction est largement inconnue en raison des nombreuses difficultés évoquées précédemment.

Objectifs: Identifier et cartographier l'état de la littérature pour les études qui explorent les méthodes d'évaluation clinique efficaces pour les patients souffrant de NTSI.

Méthode : Cette revue de portée s'est appuyée sur les lignes directrices PRISMA-ScR (*Preferred Reporting Items for Systematic Reviews and Meta-Analyses-Scoping Review*) et sur le cadre en cinq étapes proposé par Arksey et O'Malley. Les bases de données électroniques (PubMed, Embase, ScienceDirect, SPORTDiscus, PEDro, Google Scholar, Bielefeld Academic Search Engine, World Wide Science, Open Access Theses and Dissertations, EThOS) ont été consultées pour identifier des études en langue anglaise entre 2000 et 2022.

Résultats : 2998 études ont été identifiées à travers les bases de données et 51 ont été incluses au terme du processus de sélection. 54,9% (28/51) proviennent d'Europe, 45,1% (23/51) étaient des études cas témoins et 35,3% (18/51) des revues narratives. L'intervention la plus étudiée était l'imagerie diagnostique (41%, 21/51). 25 études spécifient une direction d'instabilité dont 60% (15/25) concernaient une population présentant une instabilité multidirectionnelle. Une analyse thématique des données extraites a été réalisée selon quatre catégories : anamnèse, examen physique, tests cliniques et imageries.

Conclusions : L'étiologie des NTSI est multifactorielle, tout comme leurs manifestations cliniques, ce qui rend l'examen clinique un défi pour les cliniciens. L'anamnèse du patient et l'examen physique représentent les piliers de l'examen clinique. De plus amples études sont nécessaires afin d'approfondir la compréhension de cette dysfonction et orienter les cliniciens dans son évaluation.

***Mots-clés** : Épaule, Instable, Atraumatique, Évaluation, Diagnostique.*

ABSTRACT AND KEYWORDS

Context: Non-traumatic shoulder instability (NTSI) is a significant type of shoulder instability. Due to the variability of classification systems as well as its numerous clinical forms, the diagnosis and assessment of this NTSI represent a challenge for clinicians. To date, there is no consensus on diagnostic criteria or tools to guide them. Furthermore, an accurate incidence of this disorder remains unknown due to the aforementioned difficulties.

Objectives: To identify and map the state of the literature for studies that explore effective clinical assessment methods for NTSI patients.

Method: This scoping review was based on the PRISMA-ScR (Preferred Reporting Items for Systematic Reviews and Meta-Analyses-Scoping Review) guidelines, and the five-stage framework proposed by Arksey and O'Malley. Electronic databases (PubMed, Embase, ScienceDirect, SPORTDiscus, PEDro, Google Scholar, Bielefeld Academic Search Engine, World Wide Science, Open Access Theses and Dissertations, EThOS) were searched for English-language articles and reviews from 2000 to 2022. All information regarding the diagnosis and assessment of NSTI were extracted. Citation screening was performed by two independent reviewers.

Results: 2998 studies were identified through the databases, and 51 were included at the end of the selection process. 54.9% (28/51) were from Europe, 45.1% (23/51) were case-controls studies and 35.3% (18/51) were narrative reviews. The most studied intervention was diagnostic imaging (41%, 21/51). 25 studies specified a direction of instability, of which 60% (15/25) were multidirectional instability (MDI) populations. A thematic analysis of the data in four categories was performed: clinical history, physical examination, clinical tests, and imaging examination.

Conclusions: NTSI's etiology are multifactorial as well as their clinical manifestations, which makes clinical examination a challenge for clinicians. Patient clinical history and physical examination are the cornerstones of the clinical examination. Further studies are needed to deepen the understanding of this dysfunction and provide guidance to clinicians in its assessment.

Keywords: *Shoulder, Instability, Non-traumatic, Assessment, Diagnosis.*

INTRODUCTION

The shoulder complex has the ability to lift heavy loads while maintaining a wide range of movement. Its stability is based on both active musculo-tendinous (functional) and passive capsulo-ligamentary (mechanical) systems.

This complex design makes it vulnerable to injuries and a frequent disorder is the instability that results in dislocation or subluxation.

Shoulder dislocations account for 50% of major joint dislocations in the body[1]. Most of them are due to a traumatic[2] event and in an anterior direction[3].

Acute traumatic dislocations are often reduced in emergencies after the injury mechanism is identified. The recording of such data makes it possible to quantify the incidence of traumatic dislocations and thus carry out further epidemiological studies. Non-traumatic shoulder instabilities (NTSI) are mostly manifested by repeated episodes of subluxations that do not necessarily involve a visit to an emergency department. It is therefore difficult to carry out epidemiological studies in this non-traumatic population.

The literature therefore predominantly addresses traumatic instabilities, and there is little information about the estimated 5% of shoulder dislocations that have an atraumatic etiology (e.g. minor incidents such as lifting the arm or moving during sleep)[2]. We conducted a *Rapid Review* to identify epidemiological data on the prevalence or incidence of NTSI (*search strategy on Appendix I*), but no relevant information came out of it. Therefore, the precise incidence and prevalence of NTSI were still unknown at that time.

This NTSI population can be defined as people describing an abnormal movement or position of the shoulder that results in pain, subluxations, or even dislocations and functional impairment occurring without a history of significant prior injury[4].

Since the 1980s, around 18 classifications[5] have been developed in an attempt to sort out these shoulder instabilities, but no metrics have been solidly studied. The goals of these classifications are to determine a prognosis or to identify the most appropriate treatment.

To date, two main classifications have emerged: Stanmore[6] and FEDS[7]. The assessment elements, i.e., clinical history, clinical examination, imaging, and diagnostic surgery, specific to NTSI have not been clearly identified or structured. It seems that the traumatic versus non-traumatic etiology is a major driver for the choice of treatment (surgical or conservative), and certain profiles (muscle patterning) represent a contraindication to surgery[2,8].

The Stanmore classification describes two main subgroups within the atraumatic unstable shoulders: acquired or congenital hyperlaxity and muscle patterning. Because of their low prevalence, these subgroups are poorly studied and therefore the literature on the subject is poor too. This results in the absence of a consensus or strong recommendation regarding their assessment.

The purpose of this scoping review is therefore to identify and map the state of the literature regarding studies that explore any existing assessment tool for NTSI, to provide an up-to-date synthesis of the available data, identify potential themes for systematic reviews and generate items for a consensus study on the matter.

METHODS

We conducted this review in accordance with accepted Arksey and O'Malley Scoping Review methodology[9]. All relevant studies that met inclusion or exclusion criteria (Table *1*), regardless of their quality[10], were included.

We employed a three-step approach to the search for papers. Firstly, an initial limited search on PubMed was performed to identify terms through the title and abstract of relevant studies. After this search and analysis, the final search terms were selected, and the search equation was constructed. In order to be as exhaustive as possible in the search, with the help of a documentalist, we identified the several databases including peer-reviewed and grey literature. The research equations were adapted to each databases (*Appendix I*). We then extracted and selected the results from these different databases using *Rayyan*[11] and *Zotero* software. All the steps are detailed in Figure 1.

Eligibility criteria

We included peer and non-peer reviewed studies written in English concerning any tools or criteria to assess and diagnose NTSI.

Studies that dealt with NTSI were included. Because of its higher prevalence in adolescents (i.e. 16 y.o)[12], adults and adolescents (12 y.o. and above) were included. Traumatic instability, children (under 12 y.o.), animal model-based, cadaveric, bone loss and post-surgery studies were excluded. Mixed populations (traumatic and non-traumatic) were also included in the abstract and title selection to see if independent results were present.

Table 1. Eligibility criteria.

Criterion	Inclusion	Exclusion
Time period	Studies from 2000 to 2022	
Language	English	
Type of article	Reviews or articles published in peer reviewed or non-peer-reviewed journals, master theses, doctoral thesis, conference proceedings, books, or book chapters	
Study topic	Diagnosis and/or assessment of non-traumatic shoulder instability	Bone loss population Post-operative population Management study
Population	Human Adults Adolescents (12 y.o. and above) Non-traumatic shoulder instability	Animal Cadaveric Adolescents (under 12 y.o) Traumatic shoulder instability

Information sources

The peer-reviewed research was conducted in two steps. Initially, a systematic review methodology was planned to include only peer-reviewed articles. After the first phase of the selection process, we realized that the literature was too poor in quantity and quality for this methodology. A scoping review methodology was then considered more appropriate and complementary research was embedded to collect the peer-reviewed review articles.

Relevant full-text peer-reviewed articles were identified in a search of the following databases: PubMed, EMbase, ScienceDirect, SPORTDiscus, PEDro. The reviews from complementary research were identified in a search on PubMed and Embase.

A snowball research through the references of the included studies was performed during this complementary research to include studies that would not have been collected during the database extraction. In addition, in order to be as exhaustive as possible, a search of the grey literature was carried out.

Grey literature search was carried out on Google Scholar (following *K. Godin's*[13] search method), BASE, WordWideScience, OATD and EThOS. We have also searched for studies and/or guidelines from English-written shoulder learned societies websites (*list in Appendix I*). Publications from the years 2000 to 2022 were included. The detailed combinations of keywords and search strategies are available in *Appendix I*.

Selection of sources of evidence

Following the search, all identified records of the initial article peer-review search were collated and uploaded into the *Rayyan software* and the duplicates were removed. Three reviewers (AJ, AT, TL) independently screened the studies through their titles and abstracts for assessment against the inclusion/exclusion criteria (Table *1*). The full text of selected citations were assessed in detail against the inclusion criteria by three independent reviewers (AJ, AT, TL). Reasons for exclusion of full-text papers that did not meet the inclusion criteria were recorded and reported in Figure 1. All disagreements were discussed at the end of each phase.

Concerning the grey literature, all identified records were collated and duplicates were removed. Studies from English-written shoulder learned societies websites were independently screened by two reviewers (AT, CB) and added with the other grey literature extracted studies. An identical selection process as that of the peer-reviewed search was performed by the two reviewers. Reasons for the exclusion of full-text papers that did not meet the inclusion criteria were recorded and reported in Figure 1. All disagreements were discussed at the end of each selection phase.

Finally, the complementary search was made in an identical manner as the peer-reviewed and grey literature searches.

The complete results of the search are reported in a Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) flow diagram (Figure 1).

Data extraction and synthesis

A data extraction table was developed a priori. It consistently collected data regarding the following items: (1) author, (2) year of publication, (3) country, (4) type of evidence source, (5) methodology, (6) study design, (7) population, (8) type of instability, (9) sub-groups, (10) intervention, criteria or tools used to diagnose. This framed the type of information extracted during the charting process. The charting of results was an iterative process, and the extraction table was updated and further refined as the data extraction came forward.
Following the data, a study design-specific data synthesis was performed. Reviews were synthesized into the following categories: (1) author, (2) study design, (3) intervention, and (4) result. Case reports or series, case controls, prospective cohorts and cross-sectional studies were synthesized into the following categories: (1) author, (2) study design, (3) population investigated, (4) type of instability, (5) intervention, and (6) result. All the data synthesis tables are available in *Appendix II*.
Due to the limited time available for this Master thesis, these extraction and synthesis phases were carried out by a single author (AT).
As per scoping review methodological guidelines[10], we described the extent and nature of the available evidence without appraising its quality. We used descriptive syntheses to present the results and provide a wide range of details. The results are summarized in Table *2* (study characteristics) and sorted through a thematic analysis regarding the studied intervention, the type of instability, and the subgroup (adult/adolescent; traumatic/atraumatic).

RESULTS

Selection of sources of evidence

The search yielded 2998 results, 214 duplicates were removed, and 2784 records were screened through their abstracts and titles. Finally, 224 full-text articles were reviewed, and a total of 51 publications[4,14–63] met the eligibility criteria for final inclusion. The selection process and reason for full-text exclusion are reported in Figure 1.

The authors agreed on all eligibility decisions during the discussion without the need for another person to be involved. The most common reason for exclusion was a traumatic or a mixed population (i.e. traumatic and non-traumatic) without separate analysis between traumatic and non-traumatic groups.

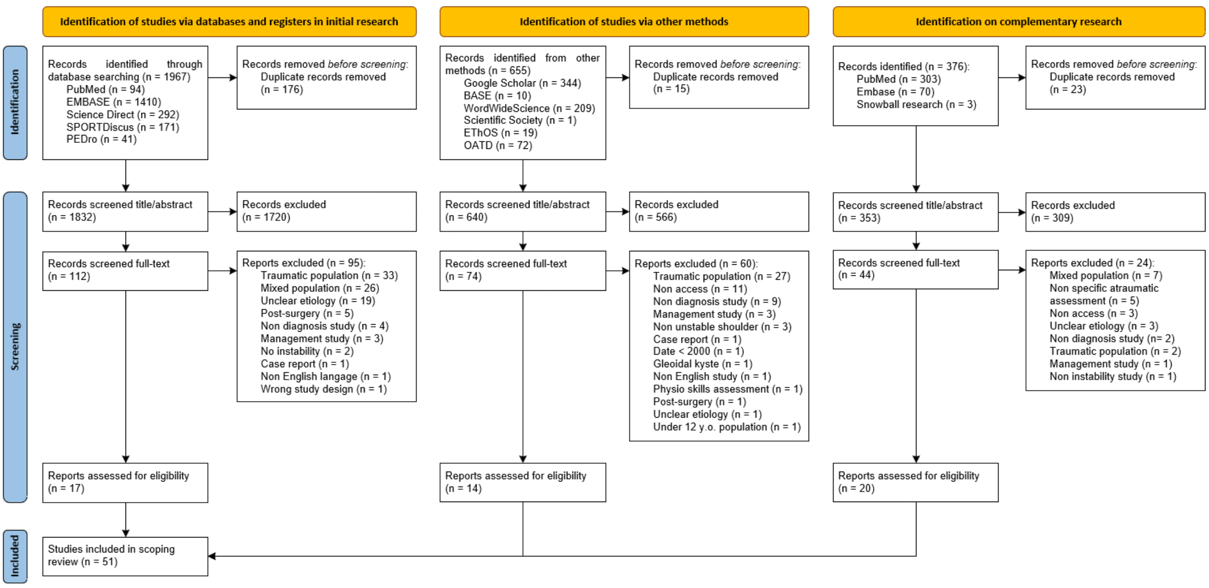

Figure 1. PRISMA flowchart

Characteristics of sources of evidence

Table *2* provides a summary of the characteristics of the 51 included studies.

The 51 included studies were published between 2000 and 2022, with about half of them prior 2012 (Figure 2). 54.9% (28/51) of the included studies came from European countries, and four continents overall published research on atraumatic shoulder instability (Figure 3). Most frequent design was case-control studies (45.1%, 23/51) followed by narrative reviews (35.3%, 18/51).

Figure 2. Summary of year publication of included studies and their direction of instability.

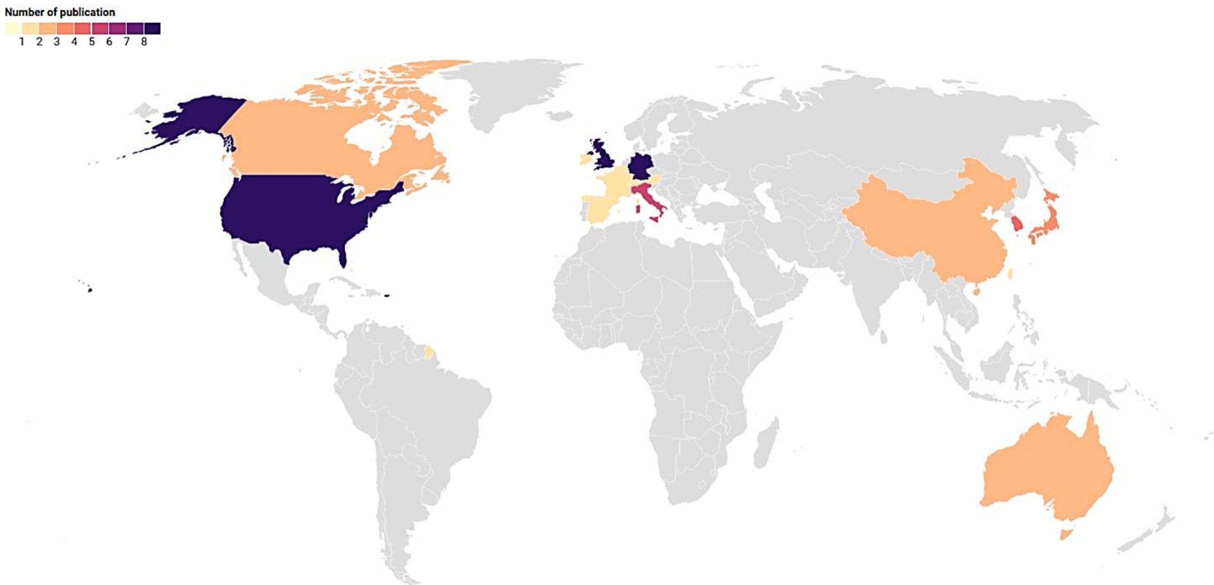

Figure 3. Summary of location publication of included studies.

As displayed in Table *2*, 15 studies examined multidirectional instability[23,24,30,37,38,40,42–46,57,58,62,63], 4 studies examined anterior instability[18,20,27,47] and 6 examined posterior instability[21,29,32,48,51,52]. 26 studies did not mention the direction of instability[4,14–17,19,22,25,26,28,31,33–36,39,41,49,50,53–56,59,61].

Diagnostic imaging was the most frequently examined intervention (41%, 21/51), followed by general reviews of shoulder instability examination (29.4%, 15/51).

Concerning the 27 clinical trials, 4 didn't have a comparative group[19,22,24,55]. Comparative groups were composed of healthy volunteers in 17 studies[14,17,18,23,26,27,30,32,37,38,40,44,47,53,57,61,63], traumatic instability patients in 8 studies[16,18,20,21,27,51,54,61], and stable shoulders with shoulder disorders such as rotator cuff tears in 7 studies[16,27,30,44,48,51,58]. 7 studies had heterogeneous several types of comparison groups[16,18,27,30,44,51,61].

The non-traumatic instability population across all included studies had a mean age of 25.93 y.o., a median age of 25 y.o. [Q25=24 ; Q75=27.5] and a standard deviation of 3.47.

The gender distribution in the studies, cumulatively in both the investigated and the comparative groups comprised 1026 males (M) and 561 females (F), which gives us an investigated population sex ratio of 1F/2M.

Table 2. Summary of included studies characteristics.

Study/article characteristics	n (%)
Total	51 (100)
Country of origin*	
Asia	10 (19.6)
Australia	2 (3.9)
Europe	28 (54.9)
North America	11 (21.6)
Type of evidence source	
Clinical trial	27 (52.9)
Discussion	1 (2)
Review	20 (39.2)
Thesis	3 (5.9)
Methodology	
Quantitative	21 (41.2)
Qualitative	24 (47.1)
Mixed methods	6 (11.8)
Study design	
Case-report or series	2 (3.9)
Case-control	23 (45.1)

Study/article characteristics	n (%)
Type of instability	
Anterior	4 (7.8)
Posterior	6 (11.8)
Multidirectional (MDI)	15 (29.4)
Unspecified	26 (51)
Studied intervention	
Arthroscopy	2 (3.9)
Diagnosing imaging	21 (41)
Electromyogram	4 (7.8)
Functional imaging	3 (5.9)
History	2 (3.9)
Motion capture	1 (2)
General review of shoulder instability exam	15 (29.4)
Orthopaedic shoulder test	3 (5.9)
Tissue analysis	1 (2)

Prospective cohort	2 (3.9)
Cross-sectional	3 (5.9)
Narrative review	18 (35.3)
Systematic review	1 (2)
Guidelines	1 (2)
Delphi	1 (2)

**Asia countries included: China, Japan, Korea, and Taiwan; European countries included: Austria, Belgium, France, Germany, Ireland, Italy, Spain, Switzerland, and UK; North American countries included: Canada and USA.*

Results of individual sources of evidence

Tables 4 to 11 in *Appendix II* extensively summarize the extracted data according to type of assessment: clinical history, physical examination, orthopaedic shoulder tests, and imaging exam. Figure 5 at the end of the results section provides a summary of these results.

CLINICAL HISTORY

Risk factors

Several risk factors may contribute to the development of NTSI. First, this dysfunction affects a large majority of young people from the adolescence to 40 y.o., and predominantly those under 25 y.o.[4,17,43,62]. *Danziger & al.*[28] states that 69% of NTSI patients have a first-time instability episode during childhood. The clinical examination of adolescents and adults is the same[49].

Most atraumatic patients will experience repeated subluxations (greater than 3 subluxations/year) rather than dislocations[4,52,56].

Chronic non-traumatic instabilities can result from a first-time traumatic episode. This puts them at high risk of recurrence, especially if this first traumatic episode occurs during childhood (86% in 15 y.o. boys, < 50% in 27 y.o. men)[49].

Warby & al.[42] suggest that non-traumatic instability evolves along a continuum from congenital laxity to acquired laxity, and from the absence of lesion to the development of lesion through repetitive stress.

Joint laxity

The hyperlaxity is a common symptom that can lead to instability in one or both shoulders due to a defect on passive stabilizers[4,28,43,45,49,56,60,62]. An histological study from Castagna &

al.[16] highlights a higher elastic fiber density in the NTSI population than in the traumatic instability group. This density was also higher in the traumatic group compared to the control group.

Patients may report "*been always flexible*"[62]. Female patients more frequently present with laxity than male[42,56].

It mainly affects the youngest people during childhood. This youngest population also has increased elastic fiber density compared to adult healthy volunteers[16]. Hyperlaxity reduces in severity after skeletal maturity and advancing to age[56]. Hyperlax patients did not necessarily have unstable shoulders[56]. Some patients with an increased humeral head translation during the clinical laxity test (*see next part*) had no instability[56].

Other comorbidities can favour NTSI like connective tissue disorders: Hypermobility-type Ehlers-Danlos syndrome, Marfan syndrome, Osteogenesis imperfecta, and benign joint hypermobility syndrome[4,49,56]. An investigation of family history and other symptomatic joints, such as repetitive ankle sprains, can be necessary to identify these disorders[45,49].

Reporting of instability during activities

The patient may report a subjective sense of instability such as popping, clicking, or grinding in association with pain during activities[45,49,50,60]. It can be during daily living activities such as opening a door, picking up something from a shelf, washing hair or grooming[49]. It can also occur during sleeping, thus causing sleep disorders that can impact the level of pain and other psychosocial parameters[4,22,45]. In the majority of cases, the instability occurs during work or sport activities[24,25,28,29,39,43,49,50,52,62] which can lead to an overuse of the shoulder, particularly in overhead activities (e.g. throwers, swimmers, overhead racquet sports or weight lifters) and in competitive sports. These patients can also relate to a decrease in strength and athletic performance in association with their pain[43]. An investigation of the level of shoulder irritability can be relevant after an instability event[62].

Psychosocial and somatosensory factors

In their study, Lebe & al.[22] highlighted that the presence of psychosocial factors was associated with negative outcome in patients with recurrent atraumatic shoulder instability. 40% of patients in their cohort had clinically relevant depression. Self-harm and suicide attempts were common symptoms. High chronic pain scores and depression were the main predictors of functional disability. Poor functional performance of the dominant arm seemed to be the driver of depressive symptoms. Psychological disorders may therefore seem to be correlated with NTSI but no causation has been identified yet[60]. These psychological comorbidities generated a vicious circle between altered quality of life, pain level and functional disability in NTSI patients.

In her review, Barrett[60] highlights somatosensory changes at a cortical level. She suggests that the assessment of chronic painful shoulder instability should extend beyond the nociceptive paradigm. A history of widespread, disabling pain, dizziness, and other characteristics such as "*the hand feels too big, puffy, swollen*" should be evaluated.

Voluntary dislocation subgroup

One of the NTSI subgroups can voluntarily dislocate their shoulder by selective muscle contraction and relaxation. Within this subgroup of patients with voluntary dislocations, Bahu & al.[45] describe two subtypes. One subtype of patient would have emotional disorders or secondary gains associated with these voluntary dislocations like the "party trick"[4,60]. Another form of voluntary dislocation would include patients with an unconscious or behavioural tic resulting in selective muscle contraction. This latter subtype would respond well to biofeedback techniques.

Patient Reported Outcome Measures (PROM)

Cunningham & al.[47] investigated PROMs in patients with anterior shoulder apprehension and their correlation to different brain areas implicated in motor, somatosensory and cognitive components. The Rowe score was the most strongly associated PROM, whereas the WOSI score and the Visual Analog Scale (VAS) a moderate correlation with all the components and the cognitive component was not as strongly associated as with the Rowe score. The Subjective Shoulder Value (SSV) and Simple Shoulder Test (SST) had the weakest correlation with the different components of shoulder apprehension.

PHYSICAL EXAMINATION

Muscle abnormalities

Electromyographic (EMG) studies that investigated muscle function found atypical muscular patterns with increased or reduced frequency and latency. It was observed in several muscles: Pectoralis Major (PM), Latissimus Dorsi (LD), Deltoid (DT), Subscapularis (SSP), Infraspinatus (IS), Supraspinatus (SSP), and Trapezius (Tr)[15,17,23,26,43,60]. There is no single muscle dysfunction that generates instabilities[26]. The atypical muscular activation pattern is a compensatory strategy in order to generate force, and clinicians may identify this strategies[60].

Visual shoulder inspection may highlight persistent hypertonic muscle or muscle atrophy[15,45,60]. Unstable patients may have muscle weakness and increased muscle fatigue which can lead to a decrease in dynamic stability[4,15,29,42,45,60].

Range of motion (ROM) and kinematic

Active ROM may be reduced while passive ROM is frequently increased because of associated joint laxity compared to a healthy shoulders[45]. Both shoulders have to be assessed[50]. Examination under anaesthesia (EUA) represents the gold standard for diagnosing joint laxity[25,45,50].

Patients can have pain or apprehension related to a specific position or movement[4,15,42,45]. The latter are dependant of the direction and severity of the instability.

Abduction and external rotation (ABER) or overhead activities may reproduce the symptoms of anterior instability. Repetitive ABER movement can increase external rotation and reduce internal rotation[39].

Flexion and internal rotation may reproduce the symptoms of posterior instability as well as posterior loading (e.g. open heavy door, push-ups, or bench presses). Finally, inferior instability symptoms may be reproduced when a patient carries a heavy object.

Altered scapular positioning or motion can be present and increase humeral head translation[42,57]. This can result in scapular winging, early scapular external rotation or, on the contrary, insufficient upward scapular rotation or increased scapular internal rotation during arm elevation in the scapular plane[15,45,46,60]. Aberrant trunk or neck motion can also be observed[60]. The extent of motion changes varied widely among indivuals[57].

Because of their pain or apprehension, unstable patients may develop kinesiophobia which will result in compensatory routines to avoid certain movements or positions[4,43,60].

Neuromotor control

Functional magnetic resonance imaging (fMRI) of NTSI patients has shown sensorimotor reorganization with increased cortical activation[26,60]. It seems to be a centrally driven inhibition, that might lead to global shoulder instability with further cortical activation occurring during unstable movement[14]. This can result in abnormal shoulder kinematics. Spanhove & al.[46] highlight increased or prolonged muscle activities that stabilize the humeral head. It reflects an attempt to control this humeral head better and longer. A higher brain activity in unstable patients suggests a harder work to achieve motor stability, even in a less cortically demanding tasks that did not involve high levels of coordination[14,26,46]. NTSI patients seems to have an increased translation of their humeral head in several ranges of motions[57,63] when compared to traumatic instability population[54].

NTSI patients may have altered proprioception that induces a poor neuromotor control[23,61].

Barrett[60] describes two movements to assess patient coordination: “angel in the snow” and “spotty dog action”. Difficulties in realizing them may suggest an alteration neuromotor control.

Neurological symptoms and associated disorders

Patients may have associated cervical spine pain[42]. Due to shoulder stress, patients can develop a thoracic outlet syndrome with neurological and vascular symptoms[4,42,50].

Inferior instability is frequently associated with neurological pain in the arm because of brachial plexus traction. Patients describe pain, paraesthesia, numbness or tingling, especially when carrying heavy objects, which may cause them to drop the object[4,42,45,49,50,62]. A neurological examination may be necessary to identify referred pain from another region. An examination of mechanosensitivity can also be relevant with nerve palpation and the upper limb nerve tension test (ULNT)[60].

ORTHOPAEDIC SHOULDER TESTS (OSTS)

Figure 4 summarizes the different OSTs mentioned in the included studies. Table *12* in *Appendix III* gives a brief description of these different OSTs and their associated studies.

These different tests can be grouped into three categories: laxity tests, provocation tests, and labral lesion tests. Laxity tests were mentioned in twelve studies[4,15,24,25,29,42,43,45,49,50,59,62], provocative tests in twelve studies[15,24,25,29,42,45,48–50,52,59,62] and the labral lesions tests in only two studies[25,59].

Regarding the provocation tests, the anterior apprehension test, the relocation test and the release test were the most mentioned tests for anterior instability. For posterior instability, the most frequently mentioned were the Jerk test and the Kim test.

Among the 14 studies that mentioned these OSTs, only 3 included measurement properties data[25,50,59]. It appears that the anterior apprehension and relocation tests are the only ones demonstrated good clinical value.

Figure 4. OSTs mentioned in the scoping review and the number of studies.

IMAGING EXAMINATION

There are no specific imaging findings in the diagnosis of NTSI[35,36,41]. There seems to be an increase in the capsular volume, and no substantial structural alteration[35,41]. The imaging exam represents a tool for therapeutic decision-making to help exclude intra-articular pathology that could further a surgical indication and a factor for failure of conservative treatment[34,36,41,45].

Imaging is not indicated for voluntary painless NTSI subgroups because there usually have no structural lesion and it will not inform the therapeutic decision[31].

Increased capsular laxity may be associated with an increased risk of MDI, particularly with redundancy of the inferior capsule or deficiency of the rotator interval[30,38,40,42–44,58].

Morpho-anatomic risk factors

Some morphologies of the glenohumeral articular structures are associated with a higher risk of developing NTSI. Increased glenoid retroversion seems to be associated with an increased risk of posterior instability[18,21,29,32,37,51]. A flatter glenoid may also be found[18,32,37,58]. This translates into a more decreased bony shoulder stability ratio (BSSR) in NTSI (-40%) than in traumatic populations (-20%) compared to a healthy population[18].

The crescent sign and triangle sign on the ABER position have a high specificity but poor sensitivity in MDI patients to detect capsular laxity[40,43].

The measurement techniques used in the assessment of capsular widening are not useful and time-consuming to diagnose redundancy of joint capsules in MDI[40].

Structural lesions

NTSI does not imply the absence of structural lesions[19]. We can thus find bone lesions[19,20] (e.g. Hill-Sachs) or ligamentous lesions[55] (e.g. middle gleno-humeral ligament = MGHL) whose severity will be less than that of traumatic instability linked to the weaker kinetics[19,20].

On the other hand, we find more labral[19,20,35,41,55] and rotator cuff[20,35,41,55] injuries in NSTI.

There are no significant imaging differences between adolescent NTSI shoulder and healthy adult shoulders[49].

Imaging techniques

Table 3 summarizes the different imaging techniques.

There are 3 main imaging modalities: radiography, computed tomography (CT) and MRI. CT and MRI can be associated with arthrography to provide more imaging details, but they are more invasive. Ultrasound is not usually used to diagnose NTSI[33].

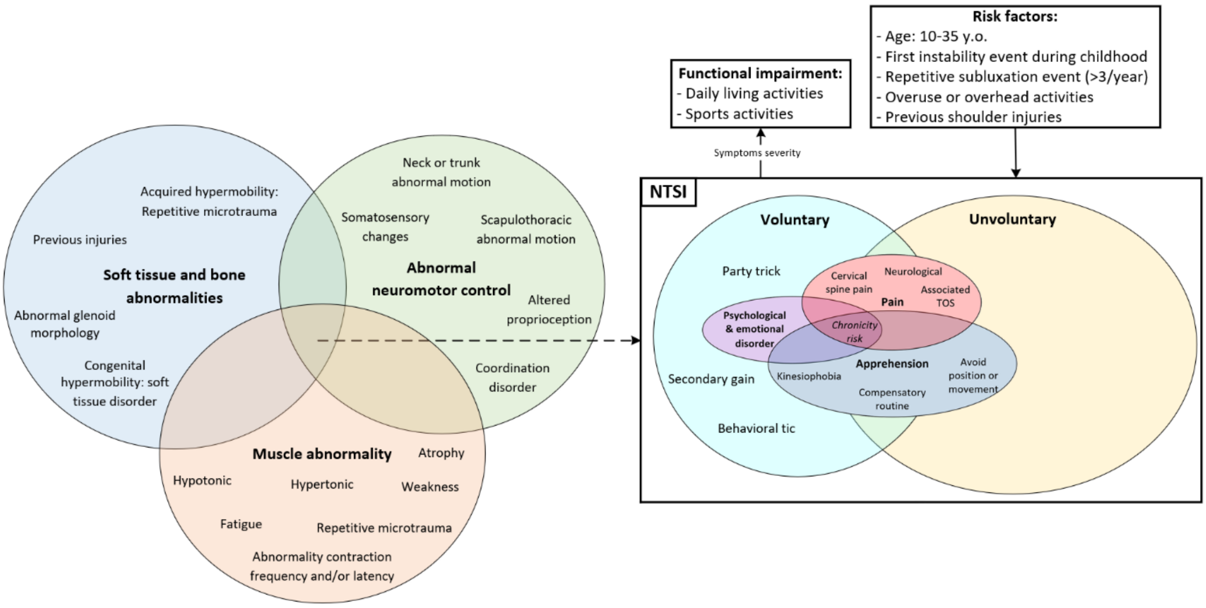

Figure 5. Venn diagram showing the known complex interaction of the different NTSI components.

Table 3. Imaging techniques.

Imaging technique	Description	Instability outcomes
Radiography [31,33,45,49,56]	- Bony lesion: large defect - AP view, True AP view (Grashey view), modified Scapular Y view (outlet view) and axillary view (west point view) - Additional projections: Bernageau's view, Stryker-Notch's view - First line	- Bony Bankart - Hill-Sachs lesion - Dislocation - Fractures - Glenoid concavity depth and retroversion
Computed Tomography (CT) [31,33,45]	- Bony lesion: small defect, quantify bone loss - MR contraindication	- Bone loss > 25% = high risk of recurrence - Bony lesion: fracture, bony Bankart, glenoid erosion, Hill-Sachs lesions, …
	Associated arthrography - Pure cartilaginous defect - Musculotendinous lesion - MR arthrography contraindication	- Cartilaginous lesion - Fracture - Dislocation - Glenoid concavity depth and retroversion - Labral lesion - Capsular redundancy
Magnetic Resonance Imaging (MRI) [31,33,34,36,41,45]	- Bony lesion - Quantify capsular-labral complex lesion - ABER position - CT contraindication	- Labral lesion : SLAP lesion, Bankart, Perthes, ALPSA, … - Bony lesion: fracture, dislocation, bone edema, bony Bankart, Hill-Sachs lesion, … - Glenoid concavity depth and retroversion - Cartilaginous defect - Ligamentous lesion - RC tears
	Associated arthrography - CT-Arthrography contraindication	- Better structural definition than MRI: capsular type, glenoid labrum, RC, morphology, GH ligaments, extent of damage - Capsular laxity: crescent sign, triangle sign, joint capsular volume with elongation inferior capsule and deficient rotator interval (GC ratio)
Ultrasound (US)[33]	- Musculotendinous lesion	- Associated RC pathology

***Abbreviation**: ABER = Abduction + External Rotation, ALPSA = Anterior Labrum Periosteal Sleeve Avulsion lesion, AP = AnteroPosterior, GC = GlenoCapsular, MR = Magnetic Resonance, RC = Rotator Cuff, SLAP lesion = Superior Labral Anterior-to-Posterior lesion*

DISCUSSION

Summary of evidence

The diagnosis of NTSI is based essentially on the clinical history and physical examination[34–36,41,45,56]. It is the result of a combination of several factors such as anatomical predispositions (acquired or congenital shoulder hypermobility, morphostatic glenoid abnormalities) and neuromotor dysfunctions. The clinical history will allow us to retrace the history of the patient's pathology through his antecedents, evolution, life habits as well as the psycho-behavioural repercussions of the latter. Patients with NTSI will essentially present repeated subluxation episodes (>3/year) rather than real dislocation. This pathology is mostly found in a young (< 25 years) and active population. Adolescence is a period of significant growth during which this population has greater joint laxity[16] and their neuromotor control continues to improve[64]. Young populations are also at greater risk because of their activities, with the practice of sports at higher frequency and intensity in a body still very malleable exposing the acquisition of hypermobility in those practising activities involving the shoulder (e.g. swimming, handball, throwing sports, volleyball, etc.).

One of the main objectives of the physical examination will be to identify compensatory strategies[4,43,60] to avoid painful and/or unstable movements or positions. Patients may adopt a protective rolling posture that may induce muscle changes such as anterior chain hypertonicity and posterior hypotonicity. Dynamically, this can be manifested by an alteration in the kinematics of the shoulder and even other joints such as the cervico-thoracic spine[60]. Deconditioning of the latter may lead to weakness and greater fatigue resulting in an increasingly significant decrease in dynamic stability[15]. The assessment of neuromotor control through functional activities, coordination exercises[60], or a double intellectual task will make it possible to investigate the patient's capacity to correctly carry out this more or less complex task and thus to evaluate his capacity to stabilise his shoulder in complex patterns.

Functional impotence will also be influenced by the cognitive-behavioural sphere[22,60]. The presence of psycho-emotional and behavioural disorders can lead to an increased perception of pain and maintain these episodes of instability. It will therefore be interesting to investigate this dimension in order to set up a multimodal approach and thus prevent the patient from becoming chronic. The clinician can use questionnaires[60] such as the Fear-Avoidance Beliefs Questionnaire[65] (FABQ), the Pain Catastrophizing Scale[66], the Hospital Anxiety and Depression score[67] (HAD) and the personal self-efficacy score[68] (PSE) in order to screen the different psycho-emotional and behavioural components.

The clinical scores are intended to evaluate and quantify the functional impotence of the shoulder in relation to this instability but are not intended to establish a diagnosis of instability. It would seem that the Rowe and the WOSI are the most relevant scores[47].

Orthopaedic shoulder tests (OST) are intended to increase or decrease the likelihood that a patient has a condition or disease, so a change in clinical management will likely be influenced by the results of these tests. The most widely accepted measures of a test's ability to exclude or confirm a disease or condition are, respectively, positive or negative likelihood ratios.

OSTs abound in the literature with over 180 identified tests[69] and are widely used by clinicians. Nevertheless, these tests are, for the most part, far from fulfilling their function as diagnostic aids due to their low validity, reliability and the low methodological quality of the studies. The patho-anatomical theories on which some tests are based on are causes of debate[69]. There is no orthopaedic gold standard test for shoulder pathology[69], only arthroscopy represents the gold standard diagnostic modality for detecting intra-articular lesions[70].

Among the reasons for the low reliability of the tests, there are few studies evaluating them individually, a low number of subjects evaluated and studies most often carried out by the authors of the tests themselves with an overestimation of the diagnostic accuracy of these tests[69,71]. Furthermore, the better the methodological quality of the studies evaluating the reliability of these tests, the more they highlight the poor reliability of the tests[71,72]. Many studies have not been blinded, do not have a control group, or involve mixed symptom populations with varying diagnoses[70]. When these studies are replicated, the metrics of these tests are frequently poorer compared to the original studies. The conclusions of various meta-analyses and systematic reviews of orthopaedic tests of other joints (e.g. lumbar, cervical, sacroiliac) are consistent with those of OST[72].

The OSTs used for the diagnosis of unstable shoulders can be grouped into three categories: laxity tests, provocation tests and tests for labral lesions.
Concerning provocation tests, only the anterior apprehension test has a good methodology and good metrological values in the diagnosis of apprehension in relation to anterior shoulder instability. It is frequently used within a cluster of two or three tests (Jobe relocation test ± release/surprise test) representing a continuum of the latter. When the apprehension test and the relocation test are combined, they have even better LR+ and LR- values[73]. Apprehension as a criterion for positivity in these tests provides better sensitivity and specificity than pain or pain + apprehension[73,74].
Tests for labral lesions focus primarily on SLAP lesions. No test can include or exclude a labral lesion with good reliability[69,70,75].
Finally, laxity tests are intended to identify joint hypermobility. Again, joint hypermobility does not necessarily imply instability. We can find an increased translation of the humeral head in its glenoid without the patient showing symptomatic instability. The use of criteria such as the patient's apprehension rather than pain or laxity when performing these laxity tests could be more relevant[76]. Furthermore, the Beighton score, frequently used in the diagnosis of generalized hyperlaxity in relation to MDIs, would correlate poorly with glenohumeral joint laxity and even less with shoulder instability[77,78]. The score was not originally designed for the diagnosis of generalised hyperlaxity[78]. Furthermore, it was established in children and also correlates poorly with lower extremity laxity[78]. And finally, the cut-off greater than or equal to 4/9 was set arbitrarily[77,78]. Only the EUA would represent the gold standard examination in the diagnosis of shoulder hyperlaxity[25,45,50].

NTSI does not imply the absence of structural injury[19]. Minor alterations of intra-articular structures may be present, such as bony[19,20] (e.g. Hill-Sachs lesion) and ligamentous[55] (e.g. MGHL) lesions, but with less severity compared to the traumatic population due to a lesser energy mechanism of injury[19,20]. The main injuries associated with NTSI are labral injuries[19,20,35,41,55], rotator cuff injuries, or biceps anchor injuries[20,35,41,55].
However, imaging is not indicated in the first line[4,33] especially since no specific imaging findings exist for NTSI[35,36,41]. Additionally, measuring capsular volume expansion is time-consuming and does not provide any additional information compared to the clinical examination in diagnosing and assessing NTSI[40]. In patients with painless voluntary

instability, imaging is even non indicated as it often appears normal and does not significantly impact the treatment decision[31].

Imaging may be considered in NTSI patients to rule out a serious underlying conditions when red flags are present[34,36,41,45], or in subacute/chronic NTSI patients who show no improvement[79]. Apart from these cases, the use of imaging is not associated with an improvement in PROMs such as pain, function, or quality of life[79]. Furthermore, the non-routinely use of imaging is associated with better results on these PROMs, particularly regarding the psycho-social impact of the latter[79,80] which can change patients' expectations and beliefs about the origin of their pain and the necessity of surgery. Additionally, other factors such as radiation exposure, increased costs and unnecessary invasive procedures might influence the clinical benefits for patients and increase the social burden of NTSI[79].

In the above-mentioned situations where imaging seems indicated, MRI provides a complete evaluation of the various structures of the shoulder[34,45]. When combined with arthrography, it offer better resolution and accuracy in identifying and quantifying lesions in the capsuloligamentous complex[31,33,36,41].

CT is indicated for assessing bony lesions, especially to quantify bone loss[33,45]. Similar to MRI, when combined with arthrography, CT-arthrography provides higher spatial and contrast resolution[31]. Therefore, both MR-arthrography and CT-arthrography are two invasive interesting modalities for identifying shoulder lesions, and the choice between them depends on contraindications and availability. Lastly, ultrasound is not indicated for NTSI except for identifying associated rotator cuff lesions[33].

Limitations

The field of research on NTSI encounters several hurdles. Firstly, the great heterogeneity in the various forms of NTSI has led to numerous evolutions in their classification. Since the Stanmore classification in 2004, MDI refers to instability in at least two directions, when it was a distinctive sign of the AMBRI group from the Thomas and Matsen classification[81]. Some authors however still use this term to refer to NTSI. We have taken these terminological variations into account by excluding articles or reviews that do not explicitly mention a non-traumatic population. Research on this non-traumatic population has long revolved around MDI, disregarding certain forms of NTSI. Furthermore, due to the low prevalence of these NTSI compared to traumatic instabilities, research on this population has been relatively limited over the years.

Recognizing the existing limitations regarding research on this condition, we opted to conduct a Scoping review in order to have an overview of the diagnosis and evaluation of this condition.

Limitations of this scoping review methodology include the possibility of missing important original documents regarding NTSI. To mitigate this risk, we conducted an extensive search across various databases and extensively explored the grey literature. For the sake of completeness in the search and to prevent the risk of missing important information, we chose to include reviews. Nevertheless, the latter are not original sources with the risk of having modified information compared to the primary sources.

Given its exploratory nature and the inherent uncertainty surrounding the expected results, it is challenging to anticipate all the details during the scoping review protocol design. Consequently, submitting it to a protocol database was complicated due to the methodological evolutions throughout implementation.

In this research master thesis, the data extraction was performed by a single individual (AT), which increases the potential for selection bias of the extracted data. To mitigate this bias, we employed a detailed chart with scrolling menus. The involvement of a second person in data selection is planned for the final publication of this article.

This study represents the initial phase of a project aimed at enhancing knowledge of NTSI and structuring the diagnosis and evaluation of this unstable population. The subsequent step will involve employing an expert consensus methodology to identify and prioritize the essential elements of NTSI assessment, thereby guiding future research in this field and offering guidance to clinicians.

CONCLUSION

The available data regarding the diagnosis and assessment of NTSI are limited, while their etiology are multifactorial and clinical manifestations diverse, which makes clinical examination a challenge for healthcare professionals. Patient clinical history and physical examination are the cornerstones of the clinical examination. Among the main predisposing factors are a young age and engaging in intensive activities that involve overhead movements. Identifying these predisposing factors, along with implementing compensatory strategies, is crucial for the diagnosis and evaluation of NTSI.

Further studies are needed to deepen the understanding of this dysfunction and provide guidance to clinicians in its assessment. The objective of identifying diagnostic and assessment elements for the preparation of an upcoming consensus study on the subject has been achieved.

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MINISTÈRE DE LA SANTÉ ET DE LA PRÉVENTION
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UNIVERSITÉ GRENOBLE ALPES
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APPENDIX

Rapport de recherche présenté par : TISSERAND Antoine

Encadré par : Thomas LATHIÈRE (Enseignant IFMK Grenoble / Kinésithérapeute D.E., MSc)

UE ATRES Année 2022 – 2023

Diplôme d'État de Masseur Kinésithérapeute

Master en Ingénierie de la Santé Parcours Kinésithérapie

Table des annexes :

APPENDIX I: Search strategy.

RAPID REVIEW

PubMed

#	Search
1	(prevalence OR incidence)[TIAB]
2	"shoulder"[TIAB]
3	(unstable OR instab* OR dislocation OR subluxate*)[TIAB]
4	(atrauma* OR non?trauma* OR trauma*)[TIAB]

INITIAL RESEARCH

PubMed

#	Search
1	assess* OR diagnos* OR triage OR evaluat* OR examin* OR investigat* OR imag* OR "clinical evaluation" OR classif*
2	"shoulder"[TIAB]
3	"non?trauma*" OR atrauma* OR habitual OR voluntary OR recurrent OR persistent OR hypermobil* OR multidirect*
4	instab* OR unstable OR sub?luxation OR dislocat*
5	clinicaltrial[Filter] OR randomizedcontrolledtrial[Filter]
7	humans[Filter]
8	2000:2022[pdat]
9	#1 and #2 and #3 and #4 and #5 and #6 and #7 and #8

EMBASE

#	Search
1	assess* OR diagnos* OR 'triage' OR triage OR evaluat* OR examin* OR investigat* OR imag* OR 'clinical evaluation' OR classif*
2	'shoulder':ab, ti
3	'non?trauma*' OR atrauma* OR habitual OR voluntary OR recurrent OR persistent OR hypermobil* OR multidirect*
4	instab*:ab, ti OR unstable:ab, ti OR sub?luxation:ab, ti OR dislocat*:ab,ti
5	'article'/it

7	[english]/lim
8	[adolescent]/lim OR [adult]/lim OR [young adult]/lim OR [middle aged]/lim OR [aged]/lim OR [very elderly]/lim
9	[humans]/lim
10	[2000-2022]/py
11	#1 and #2 and #3 and #4 and #5 and #6 and #7 and #8 and #9 and #10

ScienceDirect

#	Search
1	assess OR evaluat OR imag
2	shoulder OR glenohumeral
3	“non traumatic” OR atraumatic
4	instab OR unstable
5	Filters: 2000 to 2022, Research articles
6	#1 and #2 and #3 and #4 and #5

SPORTDiscus

#	Search
1	assess OR diagnos OR triage OR evaluat OR examination OR investigation OR imaging
2	shoulder OR glenohumeral
3	"non?traumatic" OR atraumatic OR habitual OR voluntary OR recurrent OR persistent OR hypermobil OR multidirectionnal
4	instability OR unstable OR sub?luxation OR dislocation
5	clinicaltrial[Filter] OR randomizedcontrolledtrial[Filter]
6	Filters: 2000 to 2022, language: English
7	#1 and #2 and #3 and #4 and #5 and #6

PEDro

#	Search
1	shoulder instability

GOOGLE SCHOLAR : *Following K. Godin search methology*[13]

Filter: 2000-2022
Searches "All results" - first 10 pages, representing 1000 results screened

#	Search	# results	# results screened
1	non-traumatic AND shoulder AND instability filetype:pdf		100
2	atraumatic AND shoulder AND instability filetype:pdf		100
3	atraumatic AND shoulder AND instability AND assessment filetype:pdf		100
4	non-traumatic OR atraumatic AND shoulder AND instability OR unstable filetype:pdf		100
5	non-traumatic OR atraumatic AND shoulder AND instability OR unstable AND assessment filetype:pdf		100
6	non-traumatic OR atraumatic OR recurrent AND shoulder AND instability OR unstable AND assessment filetype:pdf		100
7	(assessment OR diagnosis) AND shoulder AND (non-traumatic OR atraumatic OR recurrent) AND (instability OR unstable) filetype:pdf		100
8	(assessment OR diagnosis) AND intitle:shoulder AND (non-traumatic OR atraumatic OR recurrent) AND (instability OR unstable) filetype:pdf		100
9	allintitle:shoulder AND instability AND assessment filetype:pdf		100
10	allintitle:shoulder AND instability AND non-traumatic filetype:pdf		100
11	allintitle:shoulder AND instability AND atraumatic filetype:pdf		100

BIELEFELD ACADEMIC SEARCH ENGINE (BASE)

Filter: English

#	Search
1	Non-traumatic shoulder instability

WORD WIDE SCIENCE

Filter: English

#	Search
1	Non-traumatic shoulder instability assessment

OPEN ACCESS THESES AND DISSERTATIONS (OATD)

Filter: English only, 2000-2022

#	Search
1	shoulder instability

EThOS

#	Search
1	shoulder instability

SCIENTIFIC SHOULDER SOCIETY

Continent	Society	URL
AMERICAN	American Shoulder and Elbow Surgeons (ASES)	https://www.ases-assn.org/
	Canadian Shoulder and Elbow Society (CSES)	https://coa-aco.org/shoulder-elbow-cses/research-resources/
AFRICAN	South African Shoulder and Elbow Surgeons (SASES)	https://sases.org.za/
ASIAN	Academic Congress of Asian Shoulder and Elbow Association (ACASEA)	www.asian-shoulder.com
	Chinese Shoulder and Elbow Society (CSES)	www.cmea.org.cn
	Japan shoulder society (JSS)	https://www.j-shoulder-s.jp/english/home/index_e.html
	Korean Shoulder and Elbow Society (KSES)	https://www.kses.or.kr/eng/
	Philippine Shoulder Society (PShS)	https://www.eventcreate.com/e/philshoulderwebinar2020
	Shoulder and Elbow Society of India (SESI)	www.sesionline.in
EUROPEAN	SECEC-ESSSE	https://www.secec-essse.org/
	Belgian Elbow and Shoulder Society (BELSS)	www.bvot.be/belss
	British Elbow and Shoulder Society (BESS)	www.bess.org.uk
	ESSUER	http://www.eusser.org/
	Société Française de l'Épaule et du Coude (SoFEC)	www.asso-sofec.fr
	Shoulder Society Innsbruck (SSI)	www.shoulder.tirol
	ISES	https://isesociety.com/
OCEANIA	Australian Orthopaedic Association (AOA)	https://aoa.org.au/

	Shoulder and Elbow Society of Australia (SESA)	https://www.sesaustralia.org.au/
	New Zeland Shoulder and Elbow Society (NZSES)	https://www.nzoa.org.nz/nz-shoulder-%2B-elbow-society/2121
OTHERS	International Society of Arthroscopy, Knee Surgery and Orthopaedic Sports Medicine (ISAKOS)	www.isakos.com
	Mid-Atlantic Shoulder & Elbow Society (MASES)	http://www.mases.info/
	Codman Shoulder Society	https://www.codman-shoulder-society.com/instability

COMPLEMENTARY RESEARCH

PubMed

#	Search
1	assess* OR diagnos* OR triage OR evaluat* OR examin* OR investigat* OR imag* OR "clinical evaluation" OR classif*
2	"shoulder"[TIAB]
3	"non?trauma*" OR atrauma* OR habitual OR voluntary OR recurrent OR persistent OR hypermobil* OR multidirect*
4	instab* OR unstable OR sub?luxation OR dislocat*
5	Review[Filter]
7	humans[Filter]
8	2000:2022[pdat]
9	#1 and #2 and #3 and #4 and #5 and #6 and #7 and #8

EMBASE

#	Search
1	assess* OR diagnos* OR 'triage' OR triage OR evaluat* OR examin* OR investigat* OR imag* OR 'clinical evaluation' OR classif*
2	'shoulder':ab, ti
3	'non?trauma*' OR atrauma* OR habitual OR voluntary OR recurrent OR persistent OR hypermobil* OR multidirect*
4	instab*:ab, ti OR unstable:ab, ti OR sub?luxation:ab, ti OR dislocat*:ab,ti
5	'review'/it
7	[english]/lim

8	[adolescent]/lim OR [adult]/lim OR [young adult]/lim OR [middle aged]/lim OR [aged]/lim OR [very elderly]/lim
9	[humans]/lim
10	[2000-2022]/py
11	#1 and #2 and #3 and #4 and #5 and #6 and #7 and #8 and #9 and #10

APPENDIX II: Data extracting tables.

Table 4. Clinical history of clinical trial design.

Author (year of publication)	**Study design**	**Population investigated** (size (M/F), etiology (R/L), mean age)	**Type of instability**	**Intervention**	**Result**
Lebe & al. (2021)[22]	Cross sectional	P: n=64 (M/F=13/51), NTSI (R/L=58/6), 29.31 y.o. [16-42]. CG : N/A	N/A	History	- Frequent depression association (40%): frequent self-harm, attempted suicide. - High chronic pain score and low functional performance of the dominant arm that seems to be the driver of depressive symptoms. - Correlation between pain severity, depression severity, anxiety, and sleep disturbance.
Danzinger & al. (2019)[28]	Cross sectional	P: n=513 (M/F=208/305), healthy shoulder and FSI (R/L=459/42 + 12 bilateral side), 23 ± 4 y.o. [15-55].	N/A	History	- Epidemiology: 3.3-6.3% of FSI in maximal prevalence. - FSI population: 67% positional FSI, 50% can dislocate one shoulder and 50% both shoulders. - 28% related to a minor-trauma vs 72% related to atraumatic development. - 69% started during childhood. - 41% have general hyperlaxity. - 28% doing overhead sports and 41% > 2h/week.
Hegedus & al. (2020)[62]	Case-repot or series	P: n=1 (F), MDI (R/L: unk), 18 y.o.	MDI	Review of shoulder instability exam	- Often < 35 y.o., bilateral, multiple episodes of subluxation and level of irritability after the event, overhead sport. Patient report: "always been flexible"
Staker (2017)[24]	Cross-sectional	P: n=11 (M/F=5/6), MDI (R/L=11/0), 37.8 ± 14.5 y.o. CG: N/A	MDI	Review of shoulder instability exam	- Competitive swimming is a risk population for MDI.

***Abbreviation**: CG = Comparative Group, F = Female, FSI = Functional Shoulder Instability, L = Left, M = Male, MDI = Multidirectional Instability, n = number, P = Population, R = Right, unk = unknown.*

Table 5. Clinical history of review study design.

Author (year of publication)	**Study design**	**Intervention**	**Result**
Durazo-Romero (2015)[15]	Narrative review	Review of shoulder instability exam	- ASI: Soreness in overhead, horizontal ABD + ER. - Inferior shoulder instability: Pain with heavy objects. - PSI: Feeling pain while pushing heavy objects, flexion the arm forward or in IR position. - Recurrent instability: Weak external force generates repetitive dislocations or subluxation. - MDI (loose shoulder): Significant delay in the shoulder muscles activation time, shortened periods of activation.
Tzannes, Murrel (2022)[25]	Narrative review	Review of shoulder instability exam	- Overhead athletes: risk SLAP lesion.
Tannenbaum & al. (2011)[29]	Narrative review	Review of shoulder instability exam	- Risk factor: overuse shoulder activities (e.g. throwers, volleyball, football, tennis, swimmers, weight lifters).
Walz & al. (2015)[34]	Narrative review	Review of shoulder instability exam	- MDI: evaluation largely clinical.
Bergin (2009)[35]	Narrative review	Review of shoulder instability exam	- Risk factor: congenital hypermobile syndrome.
Chambers & al. (2013)[39]	Narrative review	Review of shoulder instability exam	- Risk factor: Overhead athletes, the throwers paradox (Wilk and Arrigo). - Subjective sense of instability.
Warby & al. (2017)[42]	Narrative review	Review of shoulder instability exam	- 12-35 y.o. (+++) - Female (higher incidence of laxity) - Multifactorial etiology - Often seen in a continuum: congenital to acquire, no lesion to lesion. - Frequent cervical spine pain and symptomatic TOS.
Merolla & al. (2015)[43]	Narrative review	Review of shoulder instability exam	- 20-30 y.o (+++) - Reported non-specific activity related pain and frequent change in lifestyle. - Frequent learning to avoid positions or developing compensatory routines. - Report of decrease strength and athletic performance associated with pain and inciting activities (overhead sport+++).
Bahu & al. (2008)[45]	Narrative review	Review of shoulder instability exam	- Symptomatic laxity in other joints (frequent ankle sprains, history of patella instability or family history of other ligament disorder). - Patient sensation: popping, clicking, grinding, pain with throwing, lifting overhead, or sleeping.
Milewski & al. (2013)[49]	Narrative review	Review of shoulder instability exam	- Activities of daily living instabilities: reaching overhead to get things from a shelf, hair washing, grooming. - Sports instabilities: overhead serving in racquet sports, swimming, weightlifting. - Occasional pain or mechanical symptoms: popping in the shoulder in particular overhead motions.

			- Other joints or family history: connective tissue disorder (Ehlers-Danlos syndrome). - High risk of recurrence after first-time instability in the young active population.
Valencia Mora & al. (2017)[50]	Narrative review	Review of shoulder instability exam	- Personal and sporting background. - Isolated or recurrent instability. - Age of first-time instability and mechanism. - Neurological complication
Johnson & al. (2010)[56]	Narrative review	Review of shoulder instability exam	- Evidence of voluntary control/muscle patterning/ social factors? - Co-existing RC impingement? - More likely to experience recurrent subluxation episodes than dislocation. - More laxity in female, Asian, African, and Middle Eastern individuals. - Connective tissue disorder: Hypermobility-type Ehlers-Danlos syndrome, Marfan syndrome, Osteogenesis imperfecta, benign joint hypermobility syndrome.
Barrett (2015)[60]	Narrative review	Review of shoulder instability exam	- Psychological disorders, emotional components. - Somatosensory change with pain impact: need to explore signs of widespread and disabling pain, dizziness and autonomic features such as "the hand feels too big, puffy, swollen".
Noorani & al. (2019)[4]	Guideline	Review of shoulder instability exam	- Predominantly < 25 y.o. - Be careful with Ehlers-Danlos Syndrome. - Repeated subluxation rather than dislocation - Central pain: burning, sharp, stabbing with associated paraesthesia or numbness - Identify TOS or neuropathic pain
Sadi & al. (2020)[52]	Delphi	Review of shoulder instability exam	- More chronic subluxation history (>3 subluxation/year). - Increased risk in performance-based sports (e.g. Dance, gymnastics) and weightlifters.

Abbreviation: *ABD = Abduction, ASI = Anterior Shoulder Instability, ER = External Rotation, MDI = Multidirectional Instability, PSI = Posterior Shoulder Instability, RC = Rotator Cuff, SLAP lesion = Superior Labral Anterior-to-Posterior lesion, TOS = Thoracic Outlet Syndrome.*

Table 6. Physical examination of clinical trial study design.

Author (year of publication)	**Study design**	**Population investigated** (size (M/F), etiology (R/L), mean age)	**Type of instability**	**Intervention**	**Result**
Howard & al. (2019)[14]	Case-control	P: n=16 (M/F=1/15), Polar type II/III instability (R/L=12/4), 24.2 ± 6.0 y.o. H-CG: n=16 (M/F=1/15), healthy shoulders (R/L=12/4), 23.8 ± 5.1 y.o.	N/A	Functional imaging	- Centrally driven inhibition that might lead to global shoulder instability with further cortical activation occurring during unstable movement. - Higher brain activity in an unstable patient suggests harder work to achieve motor stability in a lower cortical demand task that does not involves high level of coordination.
Castagna & al. (2018)[16]	Case-control	P: n=10 (M/F=10/0), MDI (R/L: unk), 30 y.o [16-42]. T-CG: n=10 (M/F=10/0), Traumatic instability (R/L: unk), 28 y.o [17-40]. H-CG: n=10 (M/F=10/0), stable shoulder (R/L: unk), 34 y.o. [16-45].	N/A	Tissue analysis	- EF density higher in youngest population of each group ($p < .05$). - EF density higher in P group compared to T-CG ($p < .001$). - EF density higher in T-CG compared to H-CG ($p < .001$).
Alexander (2007)[17]	Case-control	P: n=11 (M/F: unk), unstable shoulder (R/L: unk), [20-38] y.o. H-CG: n=8 (M/F: unk), healthy shoulders (R/L: unk), [21-50] y.o.	N/A	Electromyogram	- No UTr frequency and latency difference between groups. - LTr frequently less frequent or absent in the P group with increased latency. - General muscle decrease in excitability in P group: activation threshold increased by 20% and slower conductive pathway (increase latency)
Barden & al. (2005)[23]	Case-control	P: n=7 (M/F=7/0), MDI (R/L: unk), 25.0 ± 9.5 y.o. H-CG: n=11 (M/F=11/0), healthy shoulders (R/L: unk), 29.6 ± 9.7 y.o.	MDI	Electromyogram	- Atypical patterns of activation for SSP, IS, PD and PM muscles in P group (in ABER position). - Lack of proprioception.
Howard (2016)[26]	Case control	P: n=16 (M/F=2/14), polar type II/III instability (R/L: unk), 24.19 y.o. [16-38]. H-CG: n=16 (M/F=0/16), healthy shoulders (R/L: unk), 23 y.o. [16-31].	N/A	Electromyogram	- Motor and sensory reorganization within the P group with increase of cortical activations. - Not necessarily any single defect that generates instability in the P group. Can't conclude that muscle patterning is a compensatory mechanism. - P group had higher cortical activations; they work harder to maintain shoulder stability.

Cunningham & al. (2015)[47]	Prospective cohort	P: n=28 (M/F=28/0), ASI (R/L=18/10), 26.8 ± 1.3 y.o. [17-46]. H-CG: n=10 (M/F=10/0), 29.6 ± 1.3 y.o. (R/L=10/0).	Anterior	Functional imaging	- Pain VAS, Rowe and WOSI scores measure pain expectancy and pain-related movement induced by shoulder apprehension. - A high score means higher activities in these areas to activate these motor and cognitive processes. - Rowe score: strongest for measuring shoulder apprehension (largest number of components: sensory, motor, attention, pain anticipation) - Pain VAS and WOSI: intermediately strong scores (components: motor, sensory and cognitive). - SSV and SST: weak tests.
Von Eisenhart-Rothe & al. (2010)[57]	Case-control	P: n=14 (M/F=5/9), MDI (R/L: unk), [17-53] y.o. H-CG: n=28 (M/F=12/16), healthy shoulders (R/L: unk), [24-39] y.o.	MDI	Motion capture	- Increase glenoid retroversion and flatness of glenoid cavity in P group. - GH decentring and alteration of scapular positioning in P group. - The extent of changes varied widely among individuals.
Hegedus & al. (2020)[62]	Case-repot or series	P: n=1 (F), MDI (R/L: unk), 18 y.o.	MDI	Review of shoulder instability exam	- Global laxity (Beighton score) - Neurologic symptoms: tingling on arm

Abbreviations: *CG = Comparative Group, EF = Elastic Fibers, F = Female, H-CG: Healthy Comparative Group, L = Left, M = Male, MDI = Multidirectional Instability, n = number, NTSI = Non-Traumatic Shoulder Instability, P = Population, R = Right, SST = Simple Shoulder Test, SSV = Subjective Shoulder Value, unk = unknown, VAS = Visual Analytic Scale, WOSI = Western Ontario Shoulder Instability index.*

Table 7. Physical examination of review study design.

Author (year of publication)	**Study design**	**Intervention**	**Result**
Durazo-Romero (2015)[15]	Narrative review	Review of shoulder instability exam	- Increase risk in poor neuro-muscular control. - Kinematic: Early scapular ER, dysrhythmia of GH - Muscles abnormality: Hypertonic (e.g. PM, deltoid), atrophy (e.g. LTr), weakness, increase muscle fatigue
Tannenbaum & al. (2011)[29]	Narrative review	Review of shoulder instability exam	- Muscle fatigue leading to decreased dynamic stability. - Excessive translation doesn't confirm shoulder instability, and not all patients with PSI present excessive translation.
Walz & al. (2015)[34]	Narrative review	Review of shoulder instability exam	- Alteration in type and quantity of collagen is histologically observed.
Bergin (2009)[35]	Narrative review	Review of shoulder instability exam	- MDI: Alteration in type and quantity of collagen is histologically observed.
Chambers & al. (2013)[39]	Narrative review	Review of shoulder instability exam	- Internal impingement usually affects adults < 40 y.o. that practise activities involving repetitive ABER. - Kinematic: Decrease velocity, weakness after throwing, increase ER, decrease IR. - Posterior GH joint line tenderness.
Warby & al. (2017)[42]	Narrative review	Review of shoulder instability exam	- Altered neuromuscular control and altered scapular positioning: increase GH joint translation. - Reduce joint position sense or sensorimotor control. - Reduce muscle strength. - Inferior laxity: possible association with pain, paraesthesia, numbness when carrying heavy objects (traction brachial plexus). - ASI: overhead movement, ER. - PSI: flexion, IR, push-ups, pushing open a heavy door.
Merolla & al. (2015)[43]	Narrative review	Review of shoulder instability exam	- Hyperlaxity sign - Possible abnormality of muscle balance: hypertonic muscles (IR+++) and hypotonic muscles (ER+++)
Bahu & al. (2008)[45]	Narrative review	Review of shoulder instability exam	- Inferior shoulder instability: Associated pain, numbness, and tingling, particularly when carrying heavy objects. - ASI: symptoms in overhead throwing position (ABER). - PSI: posterior loading of shoulder(humerus fixe and IR), pushing open a door, push-ups, bench-press, blocking in football. - Voluntary SI: selective muscle contraction and relaxation (± unconscious or behavioural tic), emotional disorder or secondary gain associated. - Neurological exam: to evaluate referred pain from other regions. - Shoulder inspection: muscle atrophy, scapular winging, ROM, strength.

Spanhove & al. (2021)[46]	Systematic review	Electromyogram	- Increase or prolonged muscle activities that stabilize the HH: reflects an attempt to control the HH better and longer. - Reduced or shorter activity of muscles that move or accelerate the arm and shoulder girdle. - Increased or prolonged activity of muscles that decelerate or eccentrically control the movement of the arm and shoulder girdle. - No significant difference between health and MDI group on scapular stabilizers. - Kinematic: insufficient upward scapular rotation and increased scapular internal rotation during arm elevation in the scapular plane that suggest deficiencies in neuromuscular control.
Milewski & al. (2013)[49]	Narrative review	Review of shoulder instability exam	- MDI: Numbness in the hand while carrying heavier objects. - Same physical exam as adult for adolescent. - Less common cervical spine disorder than adults. - Hyperlaxity examination
Valencia Mora & al. (2017)[50]	Narrative review	Review of shoulder instability exam	- ROM of both shoulder, laxity - Motor and sensory testing - Clicking or catching sensation and pain.
Johnson & al. (2010)[56]	Narrative review	Review of shoulder instability exam	- Instability attributable to hyperlaxity? - If hyperlaxity, symptoms not always attributable to instability (e.g. RC impingement). - Hyperlaxity: reduction in severity after skeletal maturity, and with advancing age.
Barrett (2015)[60]	Narrative review	Review of shoulder instability exam	- Abnormal motion in muscle patterning: provocative movements, patient's willingness to move, correcting movement strategy, aberrant motion of scapula, aberrant trunk and neck motion. - Weakness, persistently hypertonic muscles, generalized joint hyperlaxity, apprehension. - Mechanosensitivity in neural tissue: ULNT, nerve palpation (neurogenic pain). - Developmental coordination/sensory motor integration: difficulties in throw, catch, angels in the snow patterns, spotty dog action and hula hooping.
Noorani & al. (2019)[4]	Guideline	Review of shoulder instability exam	- Laxity sign, possible weakness - Apprehension or feeling shoulder insecurity during movement in various positions (overhead+++) or postures at rest or during sleep. - Possible local pain localized to the long head of biceps, diffuse pain patterns through the arm to the hand, central pain. - A small cohort of voluntary dislocation ("party trick"). - A subgroup of abnormal muscle recruitment: muscle deconditioning, fear, avoidance of movement, psychosocial issues.

***Abbreviation**: ABER = Abduction + External Rotation, ASI = Anterior Shoulder Instability, CG = Comparative Group, ER = External Rotation, F = Female, FSI = Functional Shoulder Instability, GH = Gleno-Humeral, H-CG = Healthy Comparative Group, IR = Internal Rotation, L = Left, LTr = Lower Trapezius, M = Male, MDI = Multidirectional Instability, n = number, P = Population, PM = Pectoralis Major, PSI = Posterior Shoulder Instability, R = Right, RC = Rotator Cuff, ROM = Range Of Motion, SI = Shoulder Instability, ULNT = Upper Limb Nerve Tension, unk = unknown.*

Table 8. Orthopaedic shoulder test of clinical trial study design.

Author (year of publication)	**Study design**	**Population investigated** (size (M/F), etiology (R/L), mean age)	**Type of instability**	**Intervention**	**Result**
Balke & al. (2011)[61]	Case-control	P: n=24 (M/F=17/7), shoulder instability (R/L=7/11 + 6 bilateral side), 24.7 ± 5.3 y.o. - T-P: n=15 (M/F=15/2), traumatic instability (R/L=7/8) - NT-P: n=9 (M/F=2/5), anterior NTSI (L=3, 6 bilateral side). H-CG: n=24 (M/F=11/13), healthy shoulders (R/L: unk), 24.7 ± 1.1 y.o.	N/A	OST	- Proprioception deficit in instability groups than in H-CG.
Kim & al. (2004)[48]	Prospective cohort	P: n=35 (33 patients) (M/F=26/7), PSI with painful jerk test (R/L: unk), 25 y.o. [18-29]. CG: n=54 (48 patients) (M/F=31/17), PSI with painless jerk test (R/L: unk), 24 y.o. [19-31].	Posterior	OST	- Painful clunk in the jerk test is associated with structural defect: posteroinferior labral lesion. - Jerk test is a hallmark for predicting the prognosis of nonoperative treatment for posteroinferior instability.
Hegedus & al. (2020)[62]	Case-repot or series	P: n=1 (F), MDI (R/L: unk), 18 y.o.	MDI	Review of shoulder instability exam	- Apprehension test (LR+=17) - Posterior apprehension test (LR+=19) - Hyperabduction test (>105°) - A positive finding of pain instead of apprehension should be interpreted cautiously - Cluster: 2/3 positive specific test + Beighton positive
Staker (2017)[24]	Cross-sectional	P: n=11 (M/F=5/6), MDI (R/L=11/0), 37.8 ± 14.5 y.o. CG: N/A	MDI	Review of shoulder instability exam	- Laxity tests: anterior and posterior drawer test, sulcus test. - Apprehension test.

Abbreviation: *CG = Comparative Group, F = Female, H-CG = Healthy Comparative Group, L = Left, LR+ = Positive Likehood Ratio, MDI = Multidirectional Instability, M = Male, n = number, P = Population, PSI = Posterior Shoulder Instability, R = Right, unk = unknown.*

Table 9. Orthopaedic shoulder test of review study design.

Author (year of publication)	**Study design**	**Intervention**	**Result**
Durazo-Romero (2015)[15]	Narrative review	Review of shoulder instability exam	- Laxity: Load-and-shift test, Anterior drawer test, Posterior drawer test, Sulcus sign, Hyperabduction test - Provocative: Apprehension test, Relocation test, Release test, Jerk test, Flexion rotation pivot test
Tzannes, Murrel (2002)[25]	Narrative review	Review of shoulder instability exam	- Laxity: Load-and-shift test (Hawkins's grading), Drawer tests, Sulcus sign, Posterior subluxation test, EUA = gold standard - Provocative: Apprehension test, Relocation test, Release test - SLAP lesion: O'Brien test, Crank test
Tannenbaum & al. (2011)[29]	Narrative review	Review of shoulder instability exam	- Posterior drawer test - Posterior stress test - Kim test for posteroinferior instability - Jerk test
Warby & al. (2017)[42]	Narrative review	Review of shoulder instability exam	- Beighton score - Cluster for diagnose: Sulcus sign, anterior or posterior drawer tests at 10-30° and 80-120° ABD, apprehension test
Merolla & al. (2015)[43]	Narrative review	Review of shoulder instability exam	- Beighton score - Sulcus sign - The load-and-shift test - Hyperabduction test - Drawer test
Bahu & al. (2008)[45]	Narrative review	Review of shoulder instability exam	- Provocative: Apprehension test, Relocation test, Release test - Laxity: Anterior and posterior drawer test, The load-and-shift test, Sulcus sign
Milewski & al. (2013)[49]	Narrative review	Review of shoulder instability exam	- Anterior apprehension test - Jobe relocation test - Anterior and posterior load-and-shift test - Kim posterior Jerk test - Hyperabduction test - Sulcus sign - Beighton score
Valencia Mora & al. (2017)[50]	Narrative review	Review of shoulder instability exam	- Laxity: Beighton score, EUA = gold standard - ASI: Apprehension test, Relocation test, Release test - PSI: Jerk test, Kim test

Hill (2008)[59]	Narrative review	Review of shoulder instability exam	- Laxity: The load and shift test, Sulcus sign, Drawer tests, Posterior Subluxation Test, Anterior and posterior jerk test, Flexion-rotation pivot, Hyperabduction - Provocation: Apprehension/augmentation test, Relocation test, Release test, Posterior apprehension test, ABIS test - Labral lesion: Active compression, Biceps load, Crank test, Clunk test, Anterior slide
Noorani & al. (2019)[4]	Guideline	Review of shoulder instability exam	- Beighton score
Sadi & al. (2020)[52]	Delphi	Review of shoulder instability exam	- Jerk test - Kim test - Posterior apprehension test - Non-sufficient when interpreted independently for the diagnosis of PSI.

Abbreviation*: ABD = Abduction, ABIS = Abduction Inferior Stability test, ASI = Anterior Shoulder Instability, EUA = Examination Under Anaesthesia, PSI = Posterior Shoulder Instability.*

Table 10. Imaging examination of clinical trial study design.

Author (year of publication)	**Study design**	**Population investigated** (size (M/F), etiology (R/L), mean age)	**Type of instability**	**Intervention**	**Result**
Moroder & al. (2015)[18]	Case-control	P: n=30 (M/F=27/3), unilateral NTSI (no polar type III) (R/L: unk), 26.8 ± 9.1 y.o. T-CG: n=30 (M/F=27/3), traumatic instability (R/L: unk), 24.5 ± 9.0 y.o. H-CG: n=30 (M/F=27/3), healthy shoulders (R/L: unk), 26.8 ± 9.1 y.o.	Anterior	Diagnostic imaging	- Glenoid concavity depth: reduced in the T-CG (23,9%) and P group (17,9%) compared to H-CG (31,2%). - P group: significant decreased concavity retroversion. - BSSR: 40% less in P group and 20% in T-CG. - P group glenoid concavity is flattest than H-CG and T-CG.
Werner & al. (2004)[19]	Case-report or series	P: n=43 (M/F=26/17), NTSI with no response to conservative treatment (R/L: unk), 27.5 y.o. CG: N/A	N/A	Arthroscopy	- P group had labral lesions (60%), Hill-Sachs lesions (60.5%). - NTSI population must not implicate the absence of intra-articular injuries. - Severity of injuries are depending on the severity of the instability.
Zhu & al. (2014)[20]	Case-control	P: n=17 (M/F=11/6), hyperlax shoulder (R/L: unk), 34.7 y.o. T-CG: n=14 (M/F=12/2), traumatic instability (R/L: unk), 36.2 y.o.	Anterior	Arthroscopy	- Anteroinferior glenoid bone defect: P group (23.5%) < T-CG (50%). - Labral injuries: higher in P group. - Hill-Sachs: higher in T-CG (100%) than P group (64.7%) with deep and wide lesions or bony injuries in T-CG. - RC injury: higher in P group (23.5%) than T-CG (7.1%).
Katthagen & al. (2017)[21]	Case-control	P: n=21 (M/F=19/2), posterior NTSI (R/L: unk), 28 ± 11.3 y.o. T-CG: n=15 (M/F=14/1), traumatic PSI (R/L: unk), 30.3 ± 15.6 y.o.	Posterior	Diagnostic imaging	- P group was associated with higher degrees of glenoid retroversion and less favourable functional outcomes of arthroscopic posterior capsulolabral anchor repair than T-CG.
Schulz & al. (2005)[27]	Case-control	P: n=14, AMBRI. T-CG: n= 17, anterior TUBS. SD-CG1: n=29, isolated SSP tear. SD-CG2: n=21, SSC tears with or without rotator interval defect. SD-CG3: n=11, stable shoulder	Anterior	Diagnostic imaging	- P group had more superior coracoid tip position (type II=project to superior half of glenoid) than T-CG (p=.04) but no difference on the basis of coracoid type or in a comparison with H-CG. - Higher variability of coracoid tip position and the level of projection on the inferior or superior half of the glenoid may influence the site of RC tear with no influence of instability type.

		with isolated AC arthritis. H-CG: n=16, healthy shoulder. Global population parameters: M/F=80/28, [18-79] y.o., R/L=60/48			
J. Y. Ha (2019)[30]	Case-control	P: n=65 (M/F=57/8), MDI (R/L: unk), 24.5 y.o. [18-42]. CG: n=65 (M/F=57/8), normal MRA shoulder + RC tendinitis + partial RC thickness tear (R/L: unk), 27.4 y.o. [18-45].	MDI	Diagnostic imaging	- GC ratio larger in P group; threshold of 1,42 found to predict MDI presence. - Means CSA is larger in P group. - Elongation of inferior capsule and deficient rotator interval leading to inferior instability.
Inui & al. (2002)[32]	Case-control	P: n=20 (M/F=6/14), atraumatic PSI with MDI (R/L: unk), 19 y.o. [15-25]. H-CG: n=45 (M/F=20/25), healthy shoulders (R/L: unk), 22 y.o. [14-42].	Posterior	Diagnostic imaging	- Atraumatic PSI showed increased retroversion and loss of concavity at lower glenoid planes.
Seung-Ho Kim & al. (2005)[37]	Case-control	P: n=33 (M/F=28/5), recurrent atraumatic posteroinferior MDI (R/L: unk), 24 y.o. [18-30]. H-CG: n=33 (M/F=22/11), healthy shoulders (R/L: unk), 23 y.o. [17-30].	MDI	Diagnostic imaging	- P group had excessive retroversion and flattening of the chondrolabral portion of glenoid.
Celentano & al. (2022)[38]	Case-control	P: n=20 (M/F=14/6), MDI (R/L: unk), 32.68 ± 14.22 y.o. [14-60]. H-CG: n=17 (M/F=12/5), healthy shoulders (R/L: unk), 33.69 ± 13.77 y.o. [15-55].	MDI	Diagnostic imaging	- Glenoid dimension isn't linked to MDI (except for bony Bankart that strongly correlates with traumatic instability). - Increased width of axillary recess at its largest point in P group. - Inferior capsular redundancy associated with MDI. - No difference between groups on rotator interval width.
Schaeffeler & al. (2014)[40]	Case-control	P: n=21 (20 patients) (M/F=4/16], MDI (R/L=11/10), 27 y.o. [12-45]. H-CG: n=17 (M/F=12/5), healthy shoulders (R/L=11/6), 31 y.o. [20-43].	MDI	Diagnostic imaging	- Crescent and triangle sign on ABER position highly specific and poorly sensitive in MDI patients. - Measurement techniques in the assessment of capsular widening are not useful and time-consuming to diagnose redundancy of the joint capsule in MDI.

Lee & al. (2013)[44]	Case-control	P: n=47 (44 patients) (M/F=28/26), MDI (3 directions) (R/L: unk), 25 y.o. [18-45]. CG: n=40 (M/F=38/12), normal shoulders + RC tendinosis + partial RC thickness tears (R/L: unk), 36 y.o. [13-71].	MDI	Diagnostic imaging	- Larger widths and depths of rotator interval in MDI group. - Larger capsular dimensions at the inferior and posteroinferior regions in MDI group.
Weishaupt & al. (2000)[51]	Case-control	P: n=15 (M/F=8/7), atraumatic PSI (R/L=11/4), 24 y.o. [17-34] T-CG: n=15 (M/F=13/2), anterior recurrent instability (R/L=5/10), 26 y.o. [15-34]. SD-CG: n=15 (M/F=9/6), stable shoulder who had RC surgery (R/L=14/1), 43.3 y.o. [40-52].	Posterior	Diagnostic imaging	- P group usually have more glenoid retroversion than T-CG and SD-CG groups.
Kondo & al. (2004)[53]	Case-control	P: n=82 (M/F=35/47), loose shoulder = MDI (R/L: unk), 21.6 y.o. [15-41]. HCG: n=102 (M/F=52/68), healthy shoulders (R/L: unk), 22.8 y.o. [15-40].	N/A	Diagnostic imaging	- P group have more upward inclined acromion resulting in less coverage of HH by the acromion.
Von Eisenhart-Rothe & al. (2002)[54]	Case-control	P: n=10 (M/F=4/6), NTSI (R/L: 5/5), 24 y.o. [8-53 y.o.]. T-CG: n=12 (M/F=8/4), traumatic instability (R/L: 7/5), 30.33 y.o. [24-39] y.o.	N/A	Diagnostic imaging	- P group have decreased capacity to recentring HH on glenoid compared to T-CG in various arm positions and with both shoulders: alteration of neuromuscular control patterns. - T-CG group have increased anteroinferior HH translation only in functionally important arm positions.
Francavilla & al. (2010)[55]	Case-control	P: n=14 (M/F=9/5), micro-instability without dislocation history or with spontaneous dislocation (R/L: unk), 32 y.o. [20-52]. CG: N/A	N/A	Diagnostic imaging	- Labral, ligamentous (MGHL) and SSP lesions are observed in the P group.

Hsu & al. (2010)[58]	Case-control	P: n=21 (M/F=unk), MDI (R/L: 12/9), 24.4 y.o. [20-36] y.o. H-CG: n=21 (M/F=21/0), healthy shoulders (R/L: 13/8), 25.4 y.o. [20-34] y.o.	MDI	Diagnostic imaging	- P group have more flatness glenoid, weak RC muscles, poor neuromuscular control, and excessively loose capsule than H-CG.
Inui & al. (2002)[63]	Case-control	P: n=10 (M/F=3/7), MDI (R/L: unk), 19.4 y.o. [15-25]. H-CG: n=40 (M/F=23/17), healthy shoulders (R/L: unk), 23.4 y.o. [14-42].	MDI	Diagnostic imaging	- Posterior and inferior off-centered HH position in the glenoid socket in P group when arm elevated in overhead position.

Abbreviation: ABER = Abduction + External Rotation, *AC = Acromio-Clavicular, AMBRI = Atraumatic Multidirectional Bilateral Instability*, BSSR = *Bony Shoulder Stability Ratio*, *CG = Comparative Group, CSA = Cross Sectional Area, F = Female, H-CG = Healthy Comparative Group, HH = Humeral Head, L = Left, LR+ = Positive Likehood Ratio, M = Male, MDI = Multidirectional Instability, MGHL = Middle Gleno-Humeral Ligament, n = number, NTSI = Non Traumatic Shoulder Instability, P = Population, PSI = Posterior Shoulder Instability, R = Right, RC = Rotator Cuff, SSC = Subscapularis, SSP = Supraspinatus, SD-CG = Shoulder Disease Comparative Group, T-CG = Traumatic Comparative Group, TUBS = Traumatic Unilateral dislocations with a Bankart lesion requiring Surgery, unk = unknown.*

Table 11. Imaging examination of review study design.

Author (year of publication)	**Study design**	**Intervention**	**Result**
Tannenbaum & al. (2011)[29]	Narrative review	Review of shoulder instability exam	- Increase risk PSI when increasing glenoid retroversion.
Blum & al. (2000)[31]	Narrative review	Review of shoulder instability exam	- Recurrent ASI: standard X-Rays protocol often sufficient (larger defect). - Small bony defect or pure cartilaginous defect: CTA. - Soft tissue defect: MRA(+++), MRI, CTA. - Suspicion minor instability: MRA(+++), MRI, CTA. - Voluntary painless NTSI: imaging not indicated (usually any lesion).
De Filippo & al. (2020)[33]	Narrative review	Review of shoulder instability exam	- Conventional X-Rays: GH bone component, 1st level exam, AP view, true AP view (Grashey view), modified scapular Y view (outlet view) - US: not used to assess SI, for RC pathology. - MR: MRA > MRI, to quantify capsuloligamentous complex lesions. - CT: Assess bone lesion, quantify bone surface deficit (bone loss), indicate for MRI contraindication, bone defect > 25%: high rate of recurrent dislocation (67% vs 4% for minor deficit)
Walz & al. (2015)[34]	Narrative review	Review of shoulder instability exam	- MRI: used to exclude labral pathology and to attempt to evaluate capsular laxity without any standards established, ABER imaging.
Bergin (2009)[35]	Narrative review	Review of shoulder instability exam	- No specific findings to diagnose NTSI by MRI or MRA: Increased capsular volume, no or little substantial alteration of intra-articular structures. - Some damage to the RC/labrum/biceps anchor. - Image to exclude other causes of shoulder pain and instability.
Sanders & al. (2000)[36]	Narrative review	Review of shoulder instability exam	- MRA: little assistance in evaluating. - MDI patient (exclude pathology) but no specific findings for NSTI patient.
Woertler & al. (2006)[41]	Narrative review	Review of shoulder instability exam	- No specific findings to diagnose NTSI by MRI or MRA: Increased capsular volume, no substantial alteration of structures - MRA: for therapeutic decision to exclude or not significant intra-articular pathology that represent surgical indication. - Microtraumatic instability: Laxity, labral Injuries, SLAP lesion, RC tears.
Warby & al. (2017)[42]	Narrative review	Review of shoulder instability exam	- Possible GH abnormalities. - Excessive capsular redundancy (inferior capsule, deficient rotator interval).
Merolla & al. (2015)[43]	Narrative review	Review of shoulder instability exam	- Increased GH joint volume and rotator interval dimension. - Standard and ABER position imaging: crescent sign, triangle sign (HH decentring).
Bahu & al. (2008)[45]	Narrative review	Review of shoulder instability exam	- To exclude other causes of shoulder pain and instability - X-Rays: humeral head defects or glenoid bone defects (CT if present to quantify).

			- MRI: soft tissues, capsular redundancy, labral injuries. - EUA: gold standard, increase GH joint translation combined with patient history and physical exam.
Milewski & al. (2013)[49]	Narrative review	Review of shoulder instability exam	- AP view, scapular Y, axillary view but no significant imaging difference compared to healthy adult shoulder.
Johnson & al. (2010)[56]	Narrative review	Review of shoulder instability exam	- X-Rays: usually not provide additional information.

Abbreviations: *ABER = Abduction and External Rotation, AP = Antero-Posterior, ASI = Anterior Shoulder Instability, CT = Computer Tomography scan, CTA = Computer Tomography Arthrography scan, EUA = Examination Under Anaesthesia, GH = Gleno-Humeral, HH = Humeral Head, MRA = Magnetic Resonance Arthrography, MRI = Magnetic Resonance Imaging, PSI = Posterior Shoulder Instability, RC = Rotator Cuff, SLAP lesion = Superior Labral Anterior-to-Posterior lesion, X-Rays = Radiography.*

APPENDIX III: Orthopaedic Shoulder Test (OST)

Table 12. Summary of OST.

OST	Definition of test	Positive symptomatic result	Features
Laxity test			
Anterior and posterior drawer test [15,24,25,29,42,43,45,59]	Patient in supine position with arm in 80-120° abd, 0-20° flex and 0-30° ER. The examiner moves the HH forward or backward.	Increase humeral head translation.	Assess anterior and posterior shoulder laxity.
Beighton Score [4,42,43,49,50,62]	Performing of 9 manoeuvres: hyperextension of fifth finger (bilateral), apposition of the thumb to the forearm (bilateral), hyperextension of the elbows (bilateral), hyperextension of the knees (bilateral), forward flexion of the trunk	≥ 4/9	Assessing generalized joint hypermobility.
Hyperabduction test (Gagey test) [15,43,49,59,62]	Passive full GHJ abd of shoulder by the examiner.	Abd exceeded 105°.	Assess of inferior GH laxity.
The load and shift test[15,25,43,45,49,59]	Patient seated or in supine position with his arm in neutral position. The examiner moves the HH forward or backward and observes the grade of translation.	Increase HH translation and reproduce patient symptoms.	Assess of GH laxity.
Sulcus sign [15,24,25,42,43,45,49,59]	Patient sitting or standing with his arm in neutral position, the examiner grasps the patient's arm and pulls inferiorly.	Dimple or sulcus appears beneath the acromion as the HH is translated inferiorly.	Assess of inferior GH laxity.
Provocation test			
Abduction inferior stability test (ABIS)[59]	Patient in supine position with the arm abd and forearm resting on the examiner’s shoulder. Then, the examiner exerts bimanual downward force over the neck of the humerus.	Subacromial sulcus, or apprehension.	Assess inferior instability.
Anterior apprehension test[15,24,25,42,45,50,59,62]	Patient in supine position, 90° abd, 90° flex elbow, IR to ER.	Joint pain or apprehension without dislocation.	Assess of anterior GH instability.
Flexion rotation pivot test[15,59]	Patient in supine position with the arm in 90° abd and neutral rotation position with the elbow flexed 90°. The examiner then forward flexes and adducts the arm whilst exerting a	Subtle subluxation and relocation palpated.	Assess posterior instability.

	posteriorly applied force on the HH.		
Jerk test[15,29,48–50,52,59]	Patient seated with the arm in abd and IR. The examiner grasps the elbow and axially loads the humerus in a proximal position. Whilst axial loading of the humerus is maintained, the arm is moved horizontally across the body.	Sudden jerk as the humeral head sides off the back of the glenoid.	Assess posterior capsular integrity.
Kim test[29,50,52]	Patient in sitting position with the arm in 90° of abd. The examiner holds the elbow and lateral aspect of the proximal arm, and a strong axial loading force is applied. Then, when the arm in elevated 45° diagonally upward, downward and backward force is applied to the proximal arm.	Sudden onset of posterior shoulder pain.	Assess posterior instability.
Posterior subluxation test[25,29,59]	Patient in supine position with the arm in add, IR, 70-90° flex. The examiner then applies a force posterior on the patient's elbow. Then, the examiner abd and externally rotated slowly to the point of relocation, palpable with the examining hand.	Palpation of relocation point.	Assess of posterior GH instability.
Posterior apprehension test[52,59,62]	Patient in supine position. The examiners flex the humerus to 90° and internally rotate.	Apprehension	Assess of posterior GH instability.
Release test[15,25,45,50,59]	Same manoeuvre as the relocation test but the examiner withdraws his hand from the HH of the patient shoulder.	Re-initiation of apprehension following had the fowler's sign.	Assess of anterior GH instability.
Relocation test[15,25,45,49,50,59]	Patient in supine position, 90° abd, ER of apprehension test manoeuvre, posterior relocation force applied on HH by the examiner hand.	Decrease of apprehension (Fowler's sign).	Assess of anterior GH instability.
Labral lesion test			
Active compression test (O'Brien test) [25,59]	Patient seated, 90° flex, 10° add, full IR and elbow in full extension. Then downward force exerted by the examiner.	Pain inside the shoulder that is eliminated if ER.	Identify potential labral (SLAP lesion) or acromioclavicular lesions as cause for shoulder pain.
Anterior slide test[59]	Patient seated or standing, with their hands on their hips and their thumb pointing posteriorly. The examiner applies an anterosuperior force to the elbow with the patient resisting this motion.	Pain at the front of the GHJ and/or pop or click in the same area or recreates the symptoms that occur during overhead activities.	Assess labral lesion.
Biceps load[59]	Same manoeuvre as apprehension test but the patient flexes his elbow with the arm in 90° abd and externally rotated.	Pain without decrease of apprehension.	Assess SLAP lesion.

Crank test[25,59]	Patient seated, 160° abd, then axial load and rotation.	Pain during the manoeuvre with or without a click, or reproduction of the characteristic symptoms.	Identify glenoid labral tears and assess an unstable SLAP lesion.
Clunk test[59]	Patient in supine position. The examiner places one hand on the posterior aspect of the GH joint while the other hand holds the bicondylar aspect of the humerus above the elbow. Then the examiner fully abducts the arm over the patient's head while pushing anteriorly on the HH and simultaneously externally rotating the arm.	Presence of clunk or grinding sound.	Identify a SLAP lesion.

Abbreviations: *Abd = Abduction, Add = Adduction, ER = External Rotation, flex = flexion, GH = Gleno-Humeral, GHJ = Gleno-Humeral Joint, HH = Humeral Head, IR = Internal Rotation, SLAP lesion = Superior Labral Anterior-to-Posterior lesion.*