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Section: Critically Appraised Topic

Article Title: Reliability of Clinical Assessment Methods to Measure Scapular Upward Rotation: A Critically Appraised Topic

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Reliability of clinical assessment methods to measure scapular upward rotation: a critically appraised topic

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ABSTRACT

Clinical Scenario: Assessing movement of the scapula is an important component in the evaluation and treatment of the shoulder complex. Currently, gold-standard methods to quantify scapular movement include invasive technique, radiation, and 3-Dimensional motion systems. This critically appraised topic (CAT) focuses on several clinical assessment methods of quantifying scapular upward rotation with respect to their reliability and clinical utility. Clinical Question: Is there evidence for non-invasive methods that reliably assess clinical measures of scapular upward rotation in subjects with or without shoulder pathologies? Summary of Key Findings: Four studies were selected to be critically appraised. The Quality Appraisal of Diagnostic Reliability (QAREL) checklist was used to score the articles on methodology and consistency. Three of the four studies demonstrated support for the clinical question. Clinical Bottom Line: There is moderate evidence to support reliable clinical methods for measuring scapular upward rotation in subjects with or without shoulder pathology. Strength of Recommendation: There is moderate evidence to suggest there are reliable clinical measures to quantify scapular upward rotation in patients with or without shoulder pathology.

"Reliability of Clinical Assessment Methods to Measure Scapular Upward Rotation: A Critically Appraised Topic"
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CLINICAL SCENARIO:

Quantifying movement of the scapula is an important component in the evaluation and treatment of the shoulder complex due to its role in scapulohumeral rhythm during overhead motion.[1-3] Scapular upward rotation has been identified to be an essential component of glenohumeral elevation.[4] Restrictions in scapular upward rotation have been linked to pathologies such as impingement, instability, and tendinopathies.[4,5] Challenges clinicians face when measuring scapular motion include the deep position of the scapula under the overlaying musculature and soft tissue, and along with its multidirectional axis of rotation.[1,6,7] To accurately quantify scapular movement, fluoroscopy and intra-cortical pinning have been utilized as the gold-standard methods of scapular assessment.[8,9] However, due to the obstacles behind radiography and 3D instrumentation, such as radiation, invasive technique, cost for equipment, and time investment, it has become apparent that there is a clinical need for a reliable and valid non-invasive method to measure scapular kinematics.[10,11] In the literature, different assessment methods have been reported, focusing on the reliability of each respective method. In this critical appraisal topic (CAT), several methods of quantifying scapular kinematics are appraised for their respective reliability and clinical utility of each method designed to measure scapular upward rotation.

FOCUSED CLINICAL QUESTION:

Is there evidence for non-invasive methods that reliably assess clinical measures of scapular upward rotation in subjects with or without shoulder pathologies?

SUMMARY OF SEARCH: (Table 1)

- The initial literature search using the Boolean Operators: Term (TX) scapular rotation, OR TX scapular motion, AND TX upward rotation, AND TX measurement, AND TX reliability for articles published since 2007 produced 678 results.
- A second set of Boolean Operators were applied in addition to the original literature search that included: NOT TX stroke, NOT TX Palsy, published since 2010 returned 535 results.
- The 535 results from the refined literature search were reviewed for title and abstract content relevant to the clinical question.
- 46 articles were identified for further review of content and methodology. Articles from the reference lists from the 46 articles were also considered. Duplicate articles were removed.
- 25 articles were eliminated based on the exclusion criteria. The remaining 21 studies were screened for methodology and were selected for further appraisal after general clinical applicability had been determined for the assessment method. Each article was evaluated for original research and reports of reliability of an independent clinical assessment method.
- Four articles were chosen to be included in the CAT. [10,12-14] The articles completed by Johnson et al.[13] and Watson et al.[10] were selected from the reference lists of Tucker et al.[12] and De Groef et al,[14] respectively.

Evidence Appraisal:

- Each study reported reliability values for the assessment method examined in the form of intraclass correlation coefficient (ICC) values for intra-rater, inter-rater, or both. ICC values are presented in Table 3. The ICC values of an assessment method were examined for strength of reliability with values less than 0.75 being poor to moderate and values above 0.75 representing good to excellent reliability.[15]
- The Quality Appraisal of Diagnostic Reliability (QAREL) checklist was used by a single reviewer to critically appraise the four studies. The QAREL evaluates studies for diagnostic reliability through methodology and consistency.[16] A study receiving a high score is likely to satisfy a higher number of items on the checklist, indicating that the study reported on the specific methodology in the study design.[16]
- The level of evidence was determined using an adaptation of the system described by van Tulder et al.[17] The systematic approach indicates that studies with higher methodological consistency, determined by the QAREL, signifies a higher level of evidence.[17]
- A strong level of evidence was designated to an assessment method receiving above 80% on the QAREL, a moderate level of evidence was given to an assessment method receiving between 50-79%, and a limited level of evidence was assigned to an assessment method receiving below 50% on the QAREL.

Key Findings:

- All studies included in the CAT sought to quantify scapular upward rotation using a non-invasive and clinically applicable method. The studies conducted by Johnson et al.[13] and

Tucker et al.[12] determined good to excellent intra-rater reliability (ICC 0.89-0.96, 0.89-0.97 respectively) for the method of assessment based on a modified digital protractor, called an inclinometer. The other assessment method investigated in this CAT was a two gravity referenced inclinometer system, found to have good to excellent intra-rater reliability (ICC 0.88-0.94) by Watson et al.[10] but weak inter-rater reliability (ICC 0.14-0.52) by De Groef et al.[14]

- QAREL scores on the four studies ranged from 50 to 87%. Limited to moderate levels of evidence were found to exist across the four studies included in the CAT. The individual scores for each study are displayed in Table 3.
- Three of the four studies appraised demonstrated support for the clinical question (Johnson et al.,[13] Tucker et al.,[12] Watson et al.[10]), while one study did not (De Groef et al.[14]).
- A moderate level of evidence was determined in support of the clinical question. This was concluded with consideration to the QAREL scores of the three studies that exhibited support and the one opposing. The moderate QAREL average of the three studies in support (60%), versus the strong QAREL score (87%) against, indicated the level of evidence was restricted to moderate.

CLINICAL BOTTOM LINE:

There is moderate evidence to support reliable clinical methods for measuring scapular upward rotation exist when limited to a single session for the assessment of subjects with or without shoulder pathology. The clinical methods examined were found to be reliable when used

by a single-rater. Future research should aim to establish between-rater and between-session reliability.

Strength of Recommendation

There is moderate evidence to suggest there are reliable clinical measures to quantify scapular upward rotation in patients with or without shoulder pathology. The systematic approach described by van Tulder et al.[17] used to determine the moderate level of evidence is based upon an article's support for the clinical question and the methodological quality of the study.

SEARCH STRATEGY:

Terms Used to Guide Search Strategy:

- **P**atient- Subjects with or without shoulder pathologies
- **I**ntervention- Intra/Inter-rater reliability
- **C**omparison- none
- **O**utcome- scapular upward rotation

Sources of Evidence Searched:

EBSCOHOST: CINAHL, CINAHL with Full Text, MEDLINE, SPORTDiscus, Additional resources obtained via review of reference lists.

INCLUSION and EXCLUSION CRITERIA:

Inclusion Criteria:

Studies that:

- Included a clinical assessment tool for measuring scapular upward rotation

- Reported intra/inter-rater reliability values for the assessment method
- Reported on patients with or without shoulder pathology
- Used subjects 18 years of age or older
- Reported in English

Exclusion Criteria:

Studies that:

- Examined assessment methods requiring software or computer analysis
- Involved invasive procedures as a means to measure scapular movement
- Used 3-Dimensional motion analysis methods as the only method of evaluation
- Did not include reliability as an outcome of the study
- Included stroke or palsy patients
- Reported on cadaveric measurements
- Abstract only
- Not written in English

RESULTS OF SEARCH (TABLE 2)

Four relevant studies were located and categorized as shown in Table 2.

SUMMARY OF BEST EVIDENCE (TABLE 3)

IMPLICATIONS FOR PRACTICE, EDUCATION, and FUTURE RESEARCH:

The current literature suggests that there are reliable non-invasive clinical assessment methods to measure scapular upward rotation in subjects with or without shoulder pathology.

Inclinometer-based assessment performed by a single rater demonstrated high in-session reliability reported by Johnson et al.,[13] Tucker et al.,[12] and Watson et al.[10] The ICC values for each method are presented in Table 3, values above 0.75 were considered good to excellent reliability for the assessment method being tested.[15]

The modified electrical inclinometer investigated by Tucker et al. was found to have the highest intra-rater reliability (ICC 0.89-0.97) among all of the methods assessed in the CAT. The study also reported on the validity of the electrical inclinometer by comparing to measurements recorded by the modified Pro 360 digital protractor (Macklandburg Duncan, Oklahoma City, OK) as described by Johnson et al.[13] The correlation of the electrical inclinometer's static scapular measurements to those taken from the digital protractor was found to have excellent validity (*r*-values .989-0.996, $p<0.001$) in each of the scapular positions tested, presented in Table 3. These high values demonstrate the electrical inclinometer investigated by Tucker et al. to be a reliable method for quantifying scapular upward rotation.[12]

While the purpose of the study by Tucker et al. was to establish reliability and validity of the electrical inclinometer,[12] it simultaneously proposes between-session reliability of the modified digital protractor previously investigated by Johnson et al. (intra-rater ICC 0.89-0.96).[13] The notion of between-session reliability is facilitated by the high correlative values (*r*-values .989-0.996, $p<0.001$) reported by Tucker et al.[12] when validating the electrical inclinometer to the modified digital protractor. While the study by Tucker et al. evaluated subjects with no history of shoulder pathology, the study by Johnson et al. used subjects with and without shoulder pathology. The high correlative values on each respective subject population suggest that further

investigation of between-session reliability on the modified digital protractor could result in good to excellent inter-rater reliability values as well.

A different form of inclinometer-based assessment investigated in the CAT is a two inclinometer system first investigated by Watson et al., known as the "two Dr. Rippstein plurimeter-V gravity referenced analogue inclinometer system".[10] The two inclinometer system demonstrated excellent intra-rater reliability (ICC 0.88-0.94)[7] when implemented on subjects with a history of shoulder pathology but failed to replicate good reliability when examined by De Groef et al.[14] on healthy subjects. Poor intra-rater reliability (ICC 0.14-0.39) found in the first cohort of 30 middle aged women only slightly improved from poor to moderate in the second cohort (ICC 0.26-0.52) even after additional investigator training.[14] The reduced replication of reliability for the two gravity referenced inclinometer system reported by De Groef et al. suggests that the reliability of the system is limited to within session and to a single rater when used on subjects with a history of shoulder pathology.[14]

This CAT does not report on studies without limitation. A difficulty that is unanimously described in the literature surrounding non-invasive techniques in quantifying scapular movement is skin artifact.[6,8,12,13] Furthermore, postural fatigue, breathing rhythm, and body size are also limitations that studies face during measurement recording and replication of scapular movement.[11,12,14] The number of subjects in each study varied, and consistency was lacking around the number of healthy patients versus those who had a history of a shoulder pathology. More investigation is needed to determine if there is reason to suspect the clinical assessment methods included in this CAT are better fit for subjects with or without shoulder pathology.

Additionally, two studies examined static scapular measurements at rest, 60, 90, and 120 degrees of scaption, while others investigated scapular position at rest, 45, 90, and 135 degrees of glenohumeral elevation in scaption.[10,12-14] With all limitations considered, the QAREL checklist was used as an appraisal tool to assess studies on methodological quality and consistency. The checklist examined the methods of each study through procedural consistencies such as position randomization and researcher blinding.[16]

Interestingly, the study by De Groef et al. recorded the highest QAREL score (87%) of all the other articles included in the CAT, thus providing a strong level of evidence arguing against the reliability of the previously reported clinical assessment method.[10] The studies conducted by Johnson et al. and Tucker et al. each recorded equal QAREL scores of 66%, indicating acceptable methodological quality. Combined with the high correlation values of the two inclinometer systems (*r*-values .989-0.996), the moderate level of evidence supports both the digital protractor and the electric inclinometer to be reliable clinical assessment methods of scapular upward rotation.

The information included in this CAT suggests that inclinometer-based assessment is a reliable method for measuring scapular upward rotation when used in a single session by a single rater. As a clinical tool, an inclinometer is a cost-effective method of motion assessment that can be easily implemented into a practice with little training. The ability to reliably quantify scapular upward rotation is a productive step in understanding scapular kinematics and the implications of deficits in scapular motion. Inclinometer-based assessment serves to provide clinicians with a

reliable tool to measure scapular upward rotation without dedicating sizable amounts of clinical efforts.

Future research is needed to continue to understand the applicability of inclinometer-based assessment in clinical practice as an assessment tool for measuring scapular upward rotation. Between-session and between-rater reliability should be a focus of future studies as well as determining reliable measurements of dynamic scapular movement during clinical assessment. Lastly, validating a non-invasive scapular clinical assessment tool against a gold-standard device that demonstrates good criterion-validity would be valuable in helping accurately measure scapular motion. Acceptable assessment methods that carry criterion-validity for scapular motion assessment include 3D electromagnetic motion capture systems, intra-cortical bone pins during dynamic movement, or fluoroscopy.[11,18] While there are many studies in the literature focusing on the validity of scapular assessment, it is those studies that primarily focus on methods of 3D motion analysis rather than clinically applicable techniques. Therefore, establishing inclinometer-based assessment as a valid means of assessment would facilitate the clinical use of the method.

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Table 1: Flow Chart of Search.

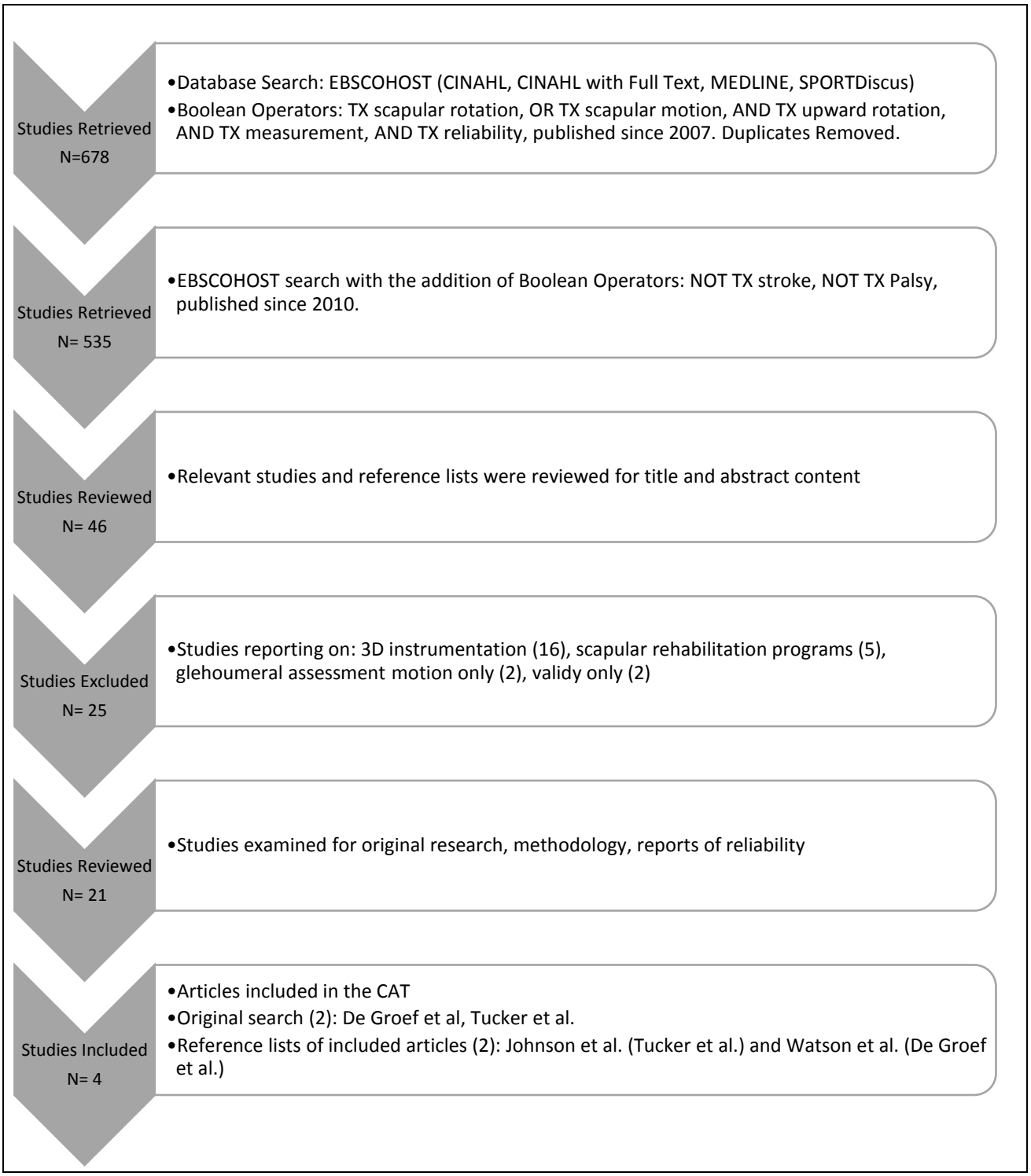

Table 2: Summary of Study Designs and articles Retrieved.

Level of Evidence*	**Study Design**	**Author (Year)**
Strong	Observational Study	De Groef et al. (2017)
Moderate	Test-retest Repeated Measures and Correlational Design	Johnson et al. (2001)
Moderate	Test-Retest Repeated Measures and Correlational Design	Tucker et al. (2012)
Limited	Test-Retest Repeated Measures	Watson et al. (2005)

*Based on the systematic approach described by van Tulder et al., 2003

Table 3: Characteristics of Included Studies.

Study	**De Groef et al.[14] (2017)**	**Johnson et al.[13] (2001)**	**Tucker et al.[12] (2012)**	**Watson et al.[10] (2005)**
Study Design	Observational Study	Test-retest Repeated Measures and Correlational Design	Test-Retest Repeated Measures and Correlational Design	Test-Retest Repeated Measures
Subjects	60 women with no history of shoulder pathology recruited in a convenience sample separated into two equal cohorts (n=30) (age 50.3 ± 7.3, 54.7 ±11.3).	39 subjects with and without (n=16, n=23) a history of shoulder pathology recruited from a convenience sample (age 35 ± 11 combined). Sex not reported.	30 males with no history of shoulder pathology (age 21.9 ±2.3).	26 subjects (11 male, 15 female) with a history of shoulder pathology recruited from a convenience sample (age 29 ± 2.5).
Pathologies Included in Subject Population	Healthy subjects only.	Shoulder impingement syndrome, rotator cuff tears, glenohumeral instability.	Healthy subjects only.	Multidirectional instability, shoulder instability, post-shoulder dislocation, overuse injury, thoracic outlet syndrome, shoulder degeneration scapular dyskinesis, SLAP lesion, impingement.
Inclusion Criteria	Report a score of 0 on the visual analogue scale for shoulder pain over the past 3 months.	For subjects with a history of pathology: • Diagnosis of pathology by an orthopaedic surgeon • ≥120° active arm elevation • Examination by PT for active arm elevation For subjects without a history of pathology: • No history of shoulder or cervical pathology requiring medical evaluation.	No prior history of shoulder pathology.	Pain and/or dysfunction in one or both shoulders, diagnosis of shoulder pathology by an orthopaedic surgeon, >140° humeral abduction.
Exclusion Criteria	A score of higher than 0 on the visual analogue scale for shoulder pain in past 3 months.	For both subjects with and without a history of shoulder pathology: • Congenital defect of the scapula • History of trauma or surgery to the rib cage or thoracic spine	History of shoulder pathology.	Congenital defect of the scapula or thorax, history of trauma, fracture, or surgery to the scapula, rib cage, thoracic spine, any evidence of peripheral or central nerve lesion, known neuromuscular

Study	**De Groef et al.[14] (2017)**	**Johnson et al.[13] (2001)**	**Tucker et al.[12] (2012)**	**Watson et al.[10] (2005)**
		• Known neuromuscular disorder(s)		disorder, <140° combined abduction, irritable shoulder condition.
Assessment Method	Two Dr. Rippstein plurimeter-V gravity referenced analogue inclinometers, described by Watson et al.[10] • One inclinometer Velcro taped perpendicular to the humeral shaft, distal to the deltoid tuberosity to measure humeral abduction. • Second inclinometer aligned manually along the scapular spine to measure scapular rotation.	A modified Pro 360 digital protractor (inclinometer) (Macklandburg Duncan, Oklahoma City, OK). • Two 10cm wooden rods with "Y-shaped" ends adjusted to the root of the scapular spine and the posterolateral acromion, respectively. • A small bubble level was attached to the left side of the inclinometer.	An electrical inclinometer modified similar to the protractor described by Johnson et al.[13] • For validity testing, the electrical inclinometer was compared to the measurements taken by the digital protractor (Johnson et al.[13])	Two Dr. Rippstein plurimeter-V gravity referenced analogue inclinometers. • One inclinometer Velcro taped perpendicular to the humeral shaft, distal to the deltoid tuberosity to measure humeral abduction. • Second inclinometer aligned manually along the scapular spine to measure scapular rotation.
Reliability Assessed	Inter-rater, single session.	Intra-rater, single session.	Intra-rater, single session.	Intra-rater, single session.
Plane of Motion **Assessed and Recorded ICC values**	Scapular *First Cohort* Rest: 0.21 45°: 0.16 90°: 0.14 135°: 0.23 Maximal flexion°: 0.39 *Second Cohort* Rest: 0.52 45°: 0.35 90°: 0.43 135°: 0.39 Maximal°: 0.26	Scapular *Dominant Arm* Rest: 0.90 60°: 0.91 90°: 0.94 120°: 0.96 *Non-Dominant* Rest: 0.89 60°: 0.89 90°: 0.89 120°: 0.90	Scapular *Dominant Arm* Rest: 0.89 60°: 0.95 90°: 0.95 120°: 0.97	Abduction Rest: 0.94 45°: 0.88 90°: 0.90 135°: 0.81 Maximal flexion (avg. 174.6°): 0.94 Overall: 0.88
Reliability Results (Meet critical value of ICC values of 0.75)[15]	Weak inter-rater reliability. Intra-rater reliability not examined.	Good to excellent intra-rater reliability. Inter-rater reliability not examined.	Good to excellent intra-rater reliability. Inter-rater reliability not examined.	Good to excellent intra-rater reliability. Inter-rater reliability not examined.

Study	**De Groef et al.[14] (2017)**	**Johnson et al.[13] (2001)**	**Tucker et al.[12] (2012)**	**Watson et al.[10] (2005)**
Validity Results	Not reported	*Comparison to 3-D magnetic tracking device expressed in r-values:* *Static* *Dominant Arm* Rest: 0.86 60°: 0.92 90°: 0.88 120°: 0.85 *Non-Dominant* Rest: 0.86 60°: 0.79 90°: 0.78 120°: 0.74 *Dynamic* *Dominant Arm* Rest: 0.72 60°: 0.73 90°: 0.73 120°: 0.72 *Non-Dominant* Rest: 0.69 60°: 0.59 90°: 0.63 120°: 0.73	*Comparison to digital protractor* ($p<0.001$) *expressed in r-values:* Rest: 0.989 60°: 0.996 90°: 0.989 120°: 0.996	Not reported
Support for the clinical question	No	Yes	Yes	Yes
QAREL Score	87%	66%	66%	50%
Level of Evidence	Strong	Moderate	Moderate	Limited

Study	**De Groef et al.[14] (2017)**	**Johnson et al.[13] (2001)**	**Tucker et al.[12] (2012)**	**Watson et al.[10] (2005)**
Conclusions	Inter-rater reliability for the gravity referenced inclinometers increased with an additional training session, though only increasing from poor to moderate reliability. Subject age, body mass, and history of shoulder pathology may interfere with reliability.	The modified digital protractor demonstrated good to excellent intra-rater reliability, suggesting a level limited to one tester. The validity of the inclinometer demonstrated good to excellent concurrent validity compared to the magnetic tracking device. The modified protractor may serve as a clinical measure to enhance treatment outcomes.	The digital inclinometer produced similar results to that of Johnson et al.,[13] though only subjects without pathology were included in the current study. The validation of the digital inclinometer in the current study may provide clinicians with a practical instrument for assessing scapular upward rotation.	The two Dr. Rippstein plurimeter-V gravity referenced analogue inclinometers can be used reliably to measure scapular upward rotation in the coronal plane. The intra-rater reliability was limited to intra-session measurements.