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

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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 3D motion systems. This critically appraised topic 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 noninvasive 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 checklist was used to score the articles on methodology and consistency. Three of the 4 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.

Keywords: scapula, CAT, clinical assessment

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 the 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 intracortical 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 noninvasive 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 critically appraised 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 noninvasive methods that reliably assess clinical measures of scapular upward rotation in subjects with or without shoulder pathologies?

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Summary of Search

- 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 (Table 1).
- The second set of Boolean Operators was applied in addition to the original literature search that included: NOT TX stroke, NOT TX Palsy, published since 2010 and returned 535 results.
- The 535 results from the refined literature search were reviewed for title and abstract content relevant to the clinical question.
- Forty-six 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.
- Twenty-five 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 the 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 al¹³ and Watson et al¹⁰ were selected from the reference lists of Tucker et al¹² and De Groef et al,¹⁴ respectively.

Evidence Appraisal

- Each study reported reliability values for the assessment method examined in the form of the intraclass correlation coefficient (ICC) values for intrarater, interrater, or both. ICC values are presented in Table 2. The ICC values of an assessment method were examined for the strength of reliability with values less than 0.75 being poor to moderate and values above 0.75 representing good to excellent reliability.¹⁵

Table 1 Flowchart of Search

Studies retrieved N = 678	<ul style="list-style-type: none"> Database search: EBSCOhost (CINAHL, CINAHL with full text, MEDLINE, and SPORTDiscus). Boolean operators: TX scapular rotation, OR TX scapular motion, AND TX upward rotation, AND TX measurement, AND TX reliability, published since 2007. Duplicates removed.
Studies retrieved N = 535	<ul style="list-style-type: none"> EBSCOhost search with the addition of Boolean operators: NOT TX stroke, NOT TX Palsy, published since 2010.
Studies reviewed N = 46	<ul style="list-style-type: none"> Relevant studies and reference lists were reviewed for title and abstract content.
Studies excluded N = 25	<ul style="list-style-type: none"> Studies reporting on 3D instrumentation (16), scapular rehabilitation programs (5), glenohumeral assessment motion only (2), and validity only (2).
Studies reviewed N = 21	<ul style="list-style-type: none"> Studies examined for original research, methodology, and reports of reliability.
Studies included N = 4	<ul style="list-style-type: none"> Articles included in the critically appraisal topic. Original search (2): De Groef et al¹⁴ and Tucker et al.¹² Reference lists of included articles (2): Johnson et al¹³ (Tucker et al¹²) and Watson et al¹⁰ (De Groef et al¹⁴).

- The quality appraisal of diagnostic reliability (QAREL) checklist was used by a single reviewer to critically appraise the 4 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, signify a higher level of evidence.¹⁷
- A strong level of evidence was designated for an assessment method receiving above 80% on the QAREL, a moderate level of evidence was given to an assessment method receiving from 50% to 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 noninvasive and clinically applicable method. The studies conducted by Johnson et al¹³ and Tucker et al¹² determined good to excellent intrarater 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 2 gravity referenced inclinometer system, found to have good to excellent intrarater reliability (ICC 0.88–0.94) by Watson et al,¹⁰ but weak interrater reliability (ICC 0.14–0.52) by De Groef et al.¹⁴
- QAREL scores on the 4 studies ranged from 50% to 87%. Limited to moderate levels of evidence were found to exist across the 4 studies included in the CAT. The individual scores for each study are displayed in Table 2.
- Three of the 4 studies appraised demonstrated support for the clinical question (Johnson et al,¹³ Tucker et al,¹² and Watson et al¹⁰), whereas 1 study did not (De Groef et al¹⁴).

- A moderate level of evidence was determined in support of the clinical question. This was concluded with consideration of the QAREL scores of the 3 studies that exhibited support and the 1 opposing study. The moderate QAREL average of the 3 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 al¹⁷ 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

- Patient: subjects with or without shoulder pathologies
- Intervention: intrarater/interrater reliability
- Comparison: none
- Outcome: scapular upward rotation

Sources of Evidence Searched

EBSCOhost: CINAHL, CINAHL with full text, MEDLINE, SPORTDiscus, and additional resources obtained via review of reference lists.

Table 2 Characteristics of Included Studies

Study	De Groef et al ¹⁴	Johnson et al ¹³	Tucker et al ¹²	Watson et al ¹⁰
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 2 equal cohorts (n = 30; age = 50.3 [7.3] and 54.7 [11.3])	39 subjects with and without (n = 16 and 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 a shoulder pathology (age = 21.9 [2.3])	26 subjects (11 males and 15 females) 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, and glenohumeral instability	Healthy subjects only	Multidirectional instability, shoulder instability, postshoulder dislocation, overuse injury, thoracic outlet syndrome, shoulder degeneration, scapular dyskinesis, labral lesion, and impingement
Inclusion criteria	Report a score of 0 on the visual analog scale for shoulder pain over the past 3 mo	For subjects with a history of pathology: <ul style="list-style-type: none"> • Diagnosis of pathology by an orthopedic surgeon • $\geq 120^\circ$ active arm elevation • Examination by physical therapist for active arm elevation For subjects without a history of pathology: <ul style="list-style-type: none"> • 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 orthopedic surgeon, $>140^\circ$ humeral abduction
Exclusion criteria	A score of higher than 0 on the visual analog scale for shoulder pain in the past 3 mo	For both subjects with and without a history of shoulder pathology: <ul style="list-style-type: none"> • Congenital defect of the scapula • History of trauma or surgery to the rib cage or thoracic spine • Known neuromuscular disorder(s) 	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 disorder, $<140^\circ$ combined abduction, irritable shoulder condition
Assessment method	Two Dr. Rippstein pluriometer-V gravity referenced analog inclinometers, described by Watson et al ¹⁰ <ul style="list-style-type: none"> • 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) <ul style="list-style-type: none"> • Two 10-cm 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 <ul style="list-style-type: none"> • For validity testing, the electrical inclinometer was compared with the measurements taken by the digital protractor (Johnson et al¹³) 	Two Dr. Rippstein pluriometer-V gravity referenced analog inclinometers <ul style="list-style-type: none"> • 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	Intrater, single session	Intrater, single session	Intrater, single session	Intrater, single session
Plane of motion	Scapular	Scapular	Scapular	Abduction
Assessed and recorded ICC values	<i>First cohort</i> Rest: 0.21 45°: 0.16 90°: 0.14 135°: 0.23 Maximal flexion°: 0.39 <i>Second cohort</i> Rest: 0.52 45°: 0.35 90°: 0.43 135°: 0.39 Maximal°: 0.26	<i>Dominant arm</i> Rest: 0.90 60°: 0.91 90°: 0.94 120°: 0.96 <i>Nondominant</i> Rest: 0.89 60°: 0.89 90°: 0.89 120°: 0.90	<i>Dominant arm</i> Rest: 0.89 60°: 0.95 90°: 0.95 120°: 0.97	Rest: 0.94 45°: 0.88 90°: 0.90 135°: 0.81 Maximal flexion (avg. 174.6°): 0.94 Overall: 0.88

(continued)

Table 2 (continued)

Study	De Groef et al ¹⁴	Johnson et al ¹³	Tucker et al ¹²	Watson et al ¹⁰
Reliability results (meet critical value of ICC values of 0.75) ¹⁵	Weak interrater reliability Intrater reliability not examined	Good to excellent intrater reliability Interrater reliability not examined	Good to excellent intrater reliability Interrater reliability not examined	Good to excellent intrater reliability Interrater reliability not examined
Validity results	Not reported	<p>Comparison to 3D magnetic tracking device expressed in <i>r</i> values:</p> <p><i>Static</i></p> <p><i>Dominant arm</i></p> <p>Rest: .86</p> <p>60°: .92</p> <p>90°: .88</p> <p>120°: .85</p> <p><i>Nondominant</i></p> <p>Rest: .86</p> <p>60°: .79</p> <p>90°: .78</p> <p>120°: .74</p> <p><i>Dynamic</i></p> <p><i>Dominant arm</i></p> <p>Rest: .72</p> <p>60°: .73</p> <p>90°: .73</p> <p>120°: .72</p> <p><i>Nondominant</i></p> <p>Rest: .69</p> <p>60°: .59</p> <p>90°: .63</p> <p>120°: .73</p>	<p>Comparison to digital protractor ($P < .001$) expressed in <i>r</i> values:</p> <p>Rest: .989</p> <p>60°: .996</p> <p>90°: .989</p> <p>120°: .996</p>	Not reported
Support for the clinical question	No	Yes	Yes	Yes
QAREL score	87%	66%	66%	50%
Level of evidence	Strong	Moderate	Moderate	Limited
Conclusions	Interrater 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 intrater reliability, suggesting a level limited to 1 tester. The validity of the inclinometer demonstrated good to excellent concurrent validity compared with 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 pluriometer-V gravity referenced analog inclinometers can be used reliably to measure scapular upward rotation in the coronal plane. The intrater reliability was limited to intrasession measurements

Abbreviations: ICC, intraclass correlation coefficient; QAREL, quality appraisal of diagnostic reliability.

Inclusion and Exclusion Criteria

Inclusion Criteria

Studies that

- Included a clinical assessment tool for measuring scapular upward rotation
- Reported intrarater/interrater 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 3D 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

Four relevant studies were located and categorized as shown in Table 3.

Summary of Best Evidence

The summary characteristics of the four articles that were included in this study are depicted in Table 2.

Implications for Practice, Education, and Future Research

The current literature suggests that there are reliable noninvasive 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 2, values above 0.75 were considered good to excellent reliability for the assessment method being tested.¹⁵

The modified electrical inclinometer (Noraxon USA Inc, Scottsdale, AZ) investigated by Tucker et al¹² was found to have the highest intrarater 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 digital protractor (Pro 360; Macklanburg-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–.996, *P* < .001) in each of the scapular positions tested, presented in Table 2. These high values demonstrate the electrical inclinometer investigated by Tucker et al¹² to be a reliable method for quantifying scapular upward rotation.

Although the purpose of the study by Tucker et al¹² was to establish reliability and validity of the electrical inclinometer, it simultaneously proposes between-session reliability of the modified digital protractor previously investigated by Johnson et al¹³ (intrarater ICC 0.89–0.96). The notion of between-session reliability is facilitated by the high correlative values (*r* values .989–.996, *P* < .001) reported by Tucker et al¹² when validating the electrical inclinometer to the modified digital protractor. Although the study by Tucker et al¹² evaluated subjects with no history of shoulder pathology, the study by Johnson et al¹³ 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 interrater reliability values as well.

A different form of inclinometer-based assessment investigated in the CAT is a 2 inclinometer system first investigated by Watson et al¹⁰ known as the “two Dr. Rippstein plurimeter-V gravity referenced analog inclinometer system.” The 2 inclinometer system demonstrated excellent intrarater 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 al¹⁴ on healthy subjects. Poor intrarater 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 2 gravity referenced inclinometer system reported by De Groef et al¹⁴ 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.

This CAT does not report on studies without limitation. A difficulty that is unanimously described in the literature surrounding noninvasive techniques in quantifying scapular movement is a 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

Table 3 Summary of Study Designs and Articles Retrieved

Level of evidence ^a	Study design	Author
Strong	Observational study	De Groef et al ¹⁴
Moderate	Test–retest repeated measures and correlational design	Johnson et al ¹³
Moderate	Test–retest repeated measures and correlational design	Tucker et al ¹²
Limited	Test–retest repeated measures	Watson et al ¹⁰

^aBased on the systematic approach described by van Tulder et al.¹⁷

shoulder pathology. More investigation is needed to determine if there is reason to suspect the clinical assessment methods included in this CAT are a better fit for subjects with or without shoulder pathology. In addition, 2 studies examined static scapular measurements at rest, 60°, 90°, and 120° of scaption, whereas others investigated scapular position at rest, 45°, 90°, and 135° 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 al¹⁴ 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 al¹³ and Tucker et al¹² each recorded equal QAREL scores of 66%, indicating acceptable methodological quality. Combined with the high correlation values of the 2 inclinometer systems (r values .989–.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 noninvasive 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, intracortical bone pins during dynamic movement, or fluoroscopy.^{11,18} Although there are many studies in the literature focusing on the validity of the 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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