Reliability and Validity of a New Method of Measuring Posterior Shoulder Tightness

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Study Design: Repeated measures of shoulder flexibility on nonimpaired subjects and intercollegiate baseball pitchers.

Objectives: To present a new objective method of measuring posterior shoulder tightness, define the intratester and intertester reliability of the measurement, and assess its construct validity.

Background: Posterior shoulder tightness has been linked to anterior humeral head translation and decreased internal rotation. The reliability of an objective assessment of posterior shoulder tightness has yet to be established in the literature.

Methods and Measures: Five repeat measurements were made using a standardized protocol on 21 nonimpaired subjects to determine intratester reliability. To determine intertester reliability, 2 testers (blinded to their measurement) each performed 1 measurement on 49 shoulders. Twenty-two intercollegiate baseball pitchers were measured once by 1 tester to evaluate the construct validity of the measurement.

Results: Measurements of posterior shoulder tightness performed by the same physical therapist had high reliability (ICC dominant = 0.92, nondominant = 0.95). Intertester measures revealed good reliability (ICC = 0.80). Pitchers had reduced dominant arm internal rotation and increased external rotation ROM compared to their other arm whereas nonimpaired subjects had less reduction in external rotation compared to the nondominant arm (pitchers: dominant, 109.7° ± 2.4°, nondominant, 98.9° ± 1.6°; nonimpaired subjects: dominant, 95.9° ± 1.5°, nondominant, 95.2° ± 1.6°) and internal rotation (pitchers: dominant, 50.0 ± 2.0°, nondominant, 69.5 ± 2.5°; nonimpaired subjects: dominant, 46.4 ± 1.3°, nondominant, 50.2 ± 1.4°). Pitchers had significantly greater posterior shoulder tightness compared to nonimpaired subjects (pitchers: dominant, 44.9 ± 0.8 cm, nondominant, 37.5 ± 0.7 cm, nonimpaired subjects: dominant, 32.9 ± 0.8 cm, nondominant, 31.4 ± 0.8 cm) and manifested a significant correlation between posterior shoulder tightness and internal rotation (r = -0.61) that was not evident in nonimpaired subjects.

Conclusions: Measurement of posterior shoulder tightness using this technique is objective and reliable when done by the same physical therapist. Validity of this measurement is supported from the observation of athletes thought to have tight posterior structures. Further study is needed to determine the relationship of this measurement to patients diagnosed with shoulder impingement syndrome. J Orthop Sports Phys Ther 1999;29:262-274.

Key Words: reproducibility, posterior capsule, flexibility

Research has documented that tight capsular and muscular tissues of the shoulder affect normal shoulder range of motion (ROM). Clinically, much attention has been given to the effect of tight posterior shoulder tissues on normal glenohumeral joint surface motion. Posterior shoulder tightness creates a need for some athletes to stretch the structures in the region of the shoulder. Clinicians, however, have yet to produce a reliable method of measuring posterior shoulder tissue tightness.

The structures of the posterior shoulder include the muscles, ligaments, nerves, and soft tissue. The posterior deltoid, infraspinatus, teres minor, and teres major may play a role in posterior shoulder tightness. The posterior capsular structures have been shown to play a significant role in allowing and controlling normal joint surface motion between the humeral head and the glenoid. Harryman et al state that oblique glenohumeral translations are not the result of ligamentous insufficiency or laxity; instead they result when the capsule is asymmetrically tight. A tight posterior capsule is thought to cause antero-superior
migration of the humeral head with forward elevation of the shoulder, possibly contributing to impingement. Tight posterior shoulder tissues may also contribute to a loss in shoulder rotation ROM, although this has not been proven.

The current methods of measuring posterior shoulder tightness are gross and inexact. Only 1 form of assessment for measuring and documenting posterior shoulder tightness has been described in the literature. Warner et al²⁵ described the following assessment of posterior shoulder tightness: horizontal flexion ROM (cross-chest adduction) is measured in the supine position with a standard goniometer. The starting point is with the shoulder flexed to 90 degrees with 0 degrees of adduction. The test proceeds with cross-chest adduction until the scapula begins to lift off the table. At this point a goniometric measurement of humeral horizontal adduction is taken. This assessment method, however, has some shortcomings. Without actual palpation of the scapula, subtle movements not visualized may influence this measurement. Warner et al²⁵ were not able to link this measurement of posterior shoulder tightness to a loss of internal rotation ROM. Reliability measurements of this technique have not been reported in the literature.

Loss of shoulder ROM in specific sports has been reported in the literature.³,⁷,⁸,¹⁶,¹⁹,²⁰,²²-²⁴,²⁶,³⁰ Specifically, loss of internal rotation has been well documented in baseball pitchers. This loss of motion is usually accompanied by a concomitant increase in external rotation in the pitching arm.³,⁷,⁸,¹⁶,¹⁹,²²,²⁴ Atwater,¹ Chandler et al,⁴ and others⁶,⁹,¹⁰ relate similar ROM findings to elite tennis players and athletes who use throwing motions in competition. Although these authors agree that internal rotation ROM is lost, they have not provided a rationale for this loss. Dines and Levinson,⁸ Jobe and Jobe,¹⁶ and others⁸⁰,⁹² advocate stretching the posterior shoulder joint tissues, as tightness in this area may be a possible cause of the loss of internal rotation ROM. The cause and effect relationship of the loss of internal rotation ROM to posterior shoulder tightness has not been objectively verified.

The purpose of our study is to develop a clinically reliable measurement tool to evaluate posterior shoulder tightness and to assess both the intratester and intertester reliability in a nonimpaired population. In addition, we assessed the tool's construct validity by using it in a population known to have decreased internal rotation ROM, possibly as a result of posterior capsule tightness.

METHODS

Subjects

This study was approved by the Institutional Review Board at the Nicholas Institute of Sports Medicine and Athletic Trauma at Lenox Hill Hospital, and informed consent was obtained prior to data collection. For the reliability study, the nonimpaired subjects consisted of 49 volunteer subjects (25 men, 24 women) with no history of shoulder pathology in the last 6 months. No subject had a history of shoulder surgery. The subjects ranged in age from 11 to 59 years old (30 ± 8.9 years [mean ± SD]). The average height was 165 ± 10 cm; the average weight was 68 ± 15 kg. The subjects for the validity study consisted of 23 male Division I intercollegiate baseball pitchers. These subjects ranged in age from 18 to 22 years (20 ± 1.2 years). The average height was 174 ± 10 cm; the average weight was 92 ± 9 kg. Ten left-handed and 13 right-handed pitchers with an average of 9 ± 1.1 years pitching experience participated. Only pitchers who were not currently having shoulder pain and those who had no significant history of shoulder injury or pain over the 6 months prior to testing were included in the study. Of the 23 pitchers tested, 1 pitcher who had a inferior capsular shift procedure on his nondominant shoulder was excluded from the study.

Equipment

A standard physical therapy plinth was used for this study. The same plinth was used for the test-retest and repeat measurements. A standard carpenter's square was used to mark the location of the medial epicondyle in relation to the surface of the plinth. The 90° angle of the square ensured that a perpendicular line from the plinth to the medial epicondyle was measured. Standard physical therapy goniometers were used to measure internal and external rotation.

New Measurement of Posterior Shoulder Tightness

The supine horizontal flexion (cross-chest adduction) position is thought to be the "gold standard" for assessing posterior shoulder tightness. Our proposed objective measurement of posterior shoulder tightness is taken in the side-lying position on a plinth (Figure 1). Male subjects have their shirts off for the test and female subjects are measured in a sports bra. The subject lies approximately ¼ the length of their humerus away from the edge of the plinth. The subject's knees and hips are passively bent to approximately 90° angles and the patient lies in such a way that they fully contact the table. The subject is aligned with bilateral acromion processes perpendicular to the plinth. The non-tested extremity is placed under the subject's head. The spine is maintained in neutral flexion, extension, and rotation. Proper positioning of the subject is crucial to a reliable measure. The medial epicondyle of the humerus is marked with a skin pencil.
I:

FIGURE 1. Illustration of the starting position for the posterior shoulder flexibility measurement with the subject positioned correctly on his side.

The tester stands facing the subject. To begin the test, the tester grasps the subject's extremity just distal to the epicondyles of the elbow. The humerus is passively moved into the starting position of 90° of abduction with the humerus in 0° internal rotation and 0° external rotation. At this point the scapula is grasped at the lateral border and stabilized in the retracted position (Figure 1). While the position of the scapula is maintained, the humerus is then passively and gently lowered into a horizontally adducted position with neutral rotation. The test is aborted and restarted if the subject is unable to relax or if the scapula cannot be stabilized effectively. The humerus is lowered until the motion has ceased or there is rotation of the humerus, indicating the end of posterior shoulder tissue flexibility (Figure 2).

At the end of the horizontal adduction ROM, a recorder places a 60-cm carpenter's square perpendicular to the table and next to the marked medial epicondyle. The recorder then marks the level of inferior border of the medial epicondyle on the carpenter's square by the recorder (Figure 3). The tester is blinded to the mark that charts the distance from the plinth to the medial epicondyle. The recorder records the distance in centimeters from the bottom of the square to the mark identifying the medial epicondyle. The distance measured indicates the amount of flexibility of the posterior shoulder tissues. A greater distance between the medial epicondyle and the plinth indicates less flexibility of the posterior shoulder tissues. Conversely, the closer the medial epicondyle falls to the table (shorter distance), the more flexible the posterior shoulder is. This measurement is taken bilaterally. The tester is not blinded to the measurements of shoulder rotation ROM.

Intratester Reliability

Intratester reliability of the posterior shoulder measurement was assessed by 1 of 2 testers (TT, TR). Both testers are physical therapists with a minimum of 5 years' experience.

One measure was taken on the dominant and non-dominant shoulders of 21 nonimpaired subjects on the same plinth on 5 consecutive days with approximately 24 hours separating each trial. The tester used a goniometer to measure passive bilateral shoulder internal rotation and external rotation at 90° abduction. The posterior shoulder tightness measurement was taken bilaterally as described in the previous section.

Intertester Reliability

Two testers (TT, TR) were involved in the assessment of intertester reliability. Fifty-six shoulders (28
TABLE 1. Intratester reliability.

<table>
<thead>
<tr>
<th></th>
<th>Mean (cm)</th>
<th>SD (cm)</th>
<th>Min (cm)</th>
<th>Max (cm)</th>
<th>Mean Co. Var.</th>
<th>ICC</th>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dominant</td>
<td>21</td>
<td>29.4</td>
<td>3.8</td>
<td>28.5</td>
<td>29.9</td>
<td>0.073 + 0.009</td>
</tr>
<tr>
<td>Nondominant</td>
<td>21</td>
<td>29.4</td>
<td>4.6</td>
<td>29.1</td>
<td>29.9</td>
<td>0.070 + 0.008</td>
</tr>
</tbody>
</table>

ICC = intraclass correlation coefficient; Mean Co. Var. = mean coefficient of variation and standard deviation (5 trials/subject); SD = standard deviation.

TABLE 2. Intertester reliability.

<table>
<thead>
<tr>
<th></th>
<th>Mean (cm)</th>
<th>SD (cm)</th>
<th>Min (cm)</th>
<th>Max (cm)</th>
<th>Co. Var.</th>
<th>ICC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tester 1</td>
<td>56</td>
<td>34.7</td>
<td>5.1</td>
<td>21.5</td>
<td>43</td>
<td>0.15</td>
</tr>
<tr>
<td>Tester 2</td>
<td>56</td>
<td>34.3</td>
<td>5.2</td>
<td>22.0</td>
<td>44</td>
<td>0.15</td>
</tr>
</tbody>
</table>

Co. Var. = coefficient of variation; ICC = intraclass correlation coefficient; SD = standard deviation.

Subjects) of the nonimpaired group were assessed. One tester assessed the posterior shoulder flexibility as outlined in the methods section to obtain 1 flexibility measurement. The second tester then repeated the measure on the same subject within 5 minutes. Both testers were blinded to the results of the measurements.

Construct Validity

We sought to validate our measurements by testing 22 male Division I college baseball pitchers and comparing these measures to the nonimpaired group. Each pitcher was evaluated by 1 therapist who obtained a single measure. Baseball pitchers are a group known to have a decrease in internal rotation ROM and an increase in external rotation ROM in the dominant arm. It has often been speculated but not substantiated objectively that the loss of internal rotation ROM in pitchers’ throwing arm is an adaptive change related to tightness of the posterior shoulder tissues.

Data Analysis

The intraclass correlation coefficient (ICC) (3,K) was used to determine the reliability of measuring posterior shoulder tightness within and between testers. An ICC of greater than 0.75 is considered good reproducibility and less than 0.75 indicates poor reproducibility. In addition, a mean coefficient of variation for the 5 intratester measures was computed for each subject. A 2-way ANOVA was used to determine differences between baseball pitchers and nonimpaired subjects and the effect of dominance on internal rotation ROM, external rotation ROM, and posterior shoulder flexibility. F-ratios indicating a significant effect of dominance were tested within groups by paired t-tests. Finally, a Pearson’s product moment r was used to determine if a relationship existed between shoulder rotation ROM and posterior shoulder tightness for each group. All values are shown as mean ± standard deviation of the mean (SD), and alpha was set at P < .05.

RESULTS

Intratester Reliability

A summary of the data is shown in Table 1 for the intratester comparison. The results indicate high reliability for both arms when the same tester measures posterior shoulder tightness in the same subject on repeated trials (ICC dominant = 0.92, nondominant = 0.95).

Intertester Reliability

Table 2 presents the data for the intertester comparison. These data indicate good intertester reliability between the 2 testers (ICC = 0.80). Therefore, 2 testers measuring posterior shoulder tightness from the same group can expect to find similar measurements. Figure 4 is a scatter plot of the intertester measures (r² = 0.461, P < .001).

Construct Validity

Figures 5 to 7 present measurements of posterior shoulder tightness, internal rotation ROM, and external rotation ROM.
nal rotation ROM bilaterally in nonimpaired subjects and pitchers. The results show a significant effect of dominance for all measurements in both groups, except for external rotation ROM in the nonimpaired subjects (F = 0.314, df = 1.47, P = .578). All measurements showed a significant difference between the groups. The baseball pitchers had significantly more external rotation ROM (pitchers: dominant, 109.7° ± 2.4°; nondominant, 98.9° ± 1.6°; nonimpaired subjects: dominant, 95.9° ± 1.5°; nondominant, 95.2° ± 1.6°), a concomitant decrease in internal rotation ROM (pitchers: dominant, 50.0° ± 2.0°; nondominant, 69.5° ± 2.5°; nonimpaired subjects: dominant, 46.4° ± 1.3°; nondominant, 50.2° ± 1.4°), and increased posterior shoulder tightness (pitchers: dominant, 44.9 ± 0.8 cm; nondominant, 37.5 ± 0.7 cm; nonimpaired subjects: dominant, 32.9 ± 0.8 cm; nondominant, 31.4 ± 0.8 cm) as compared to the age-matched nonimpaired subjects (F = 53.4, df = 1.69, P < .001). All values indicate means and standard deviations.

The scatter plot in Figure 8 represents the inverse relationship between lower internal rotation ROM to greater posterior shoulder tightness (r = -0.610, P = .003) in pitchers. No statistically significant relationship was found between external rotation ROM and posterior shoulder tightness (r = -0.153, P = .496). Conversely, the nonimpaired subjects exhibited a significant inverse correlation between external rotation ROM and posterior shoulder tightness (r = -0.460, P = .001) with no statistically significant relationship between internal rotation ROM and posterior shoulder tightness (r = -0.235, P = .107).

DISCUSSION

Our ability to document pathology and assess treatment is dictated by the validity and reliability of the measurement tools used in a clinical study. Posterior shoulder tightness is thought to be a possible cause of lost internal rotation ROM. It has been postulated, although previously unmeasured, that the loss of internal rotation ROM in the throwing arm of baseball pitchers is the result of tightness in the posterior capsule.29,30,31 Range of motion can be measured objectively with a goniometer, but until now a valid and reliable measurement of posterior shoulder tightness had yet to be established.

In previous studies the methods used to evaluate
The flexibility of the posterior shoulder have not been precise.\textsuperscript{50,55} Warner et al\textsuperscript{55} used the cross-chest adduction test in the supine position and, measuring with a goniometer, moved the tested arm into horizontal flexion until the scapula began to lift off the table. The lifting of the scapula indicated the end of posterior shoulder flexibility and the contribution of scapulothoracic motion. Warner et al\textsuperscript{55} did not account for glenohumeral rotation nor did they closely monitor scapular motion that may occur beneath the skin prior to lifting off the table. Furthermore, a goniometric measurement of horizontal flexion may be inaccurate because of the difficulty of keeping the fulcrum aligned on the glenohumeral joint while keeping the arms of the goniometer aligned with bony landmarks. Similarly, Pappas et al\textsuperscript{30} assessed posterior shoulder tightness in baseball pitchers by measuring supine subjects with a goniometer while manually stabilizing their scapula. A disadvantage of this technique is the inability to palpate and determine a reliable starting position of the scapula. A scapula starting in a more protracted position in a retest trial may be mistaken for increased posterior shoulder flexibility. The reliability for the cross-chest adduction measurement has not been determined.

Our objective measurement of posterior shoulder tightness has several advantages. Our results showed excellent reproducibility; in addition, our method allows the tester to constantly monitor scapulothoracic motion, thus ensuring that any increase in glenohumeral motion reflects posterior shoulder tissue flexibility. When we measure from a side-lying position, the scapula lies fully retracted, thereby reproducing the scapular starting position for each test. In addition, this method gives the tester the ability to detect glenohumeral rotation. The possibility of inexact goniometric measurement is eliminated by measuring the elbow height in centimeters.

The validity of goniometry has been well documented in the literature.\textsuperscript{2,12,14} Our measurement has limitations similar to goniometric measures. Goniometry is simply a measurement of joint motion. It is known that several restraints, including muscles, cartilage, ligaments, and joint capsules, limit joint motion. Goniometry, however, does not specifically measure tightness. Although O'Brien et al\textsuperscript{10} demonstrated that the posterior capsule is the primary restraint to any posterior force when the arm is positioned at 90\textdegree\ of abduction or below, we do not know that 1 structure is responsible for the tightness. Similarly, our posterior shoulder measurement cannot identify which structures are responsible for limiting motion. It is likely that the primary structure that limits motion during the test is the posterior capsule of the shoulder.

Reliability of our measurement of posterior shoulder tightness is similar to that of goniometric measurement. Range of motion measured using a standard goniometer in a test–retest design with short intervals separating the tests has been shown to be an excellent way of achieving high intratester reliability.\textsuperscript{12} Boone et al\textsuperscript{2} found that the variation among the goniometric measurements taken by 1 tester is less than that of the measurements taken by several testers. These authors concluded that to document change differences of 5\textdegree\ or more must be found between testers and 3.8\textdegree\ within testers.

Our results demonstrated high reliability for both arms when the same tester measured the same subject on repeated trials. The results of our intertester data was reproducible with an ICC = 0.80. Although we found good reliability between the 2 testers, we believe that 2 clinicians are not likely to be as consistent as 1 tester on an individual patient. We recommend that the same tester make repeated measures on a patient.

Having determined the reliability of the measurement, we next attempted to assess the construct validity of the measurement by comparing the dominant arms of a nonimpaired group and baseball pitchers—people thought to have a tight posterior capsule. Our findings for internal rotation and external rotation ROM were consistent with that of many researchers who found increased external rotation ROM and decreased internal rotation ROM in the dominant arm of elite pitchers and tennis players.\textsuperscript{9,11,21,24,50,31} Our results also showed increased posterior shoulder tightness in the dominant arm of pitchers.

A baseball pitcher needs a greater external rotation in order to generate torque and arm speed in the throwing motion. Average angular velocities in pitchers have been documented to be as high as 6000°/s of internal rotation and a maximum range of motion of 160° to 180° of external rotation.\textsuperscript{31} While performing activities of daily living, individuals do not need much more than 90° to 100° of external rotation ROM and rarely approach the high speeds in arm motion that the pitching motion produces. According to Pappas et al,\textsuperscript{30} increased flexibility in one direction may result in a compensatory decrease in the other component so that the movement can be achieved.

Comparison of the groups showed that pitchers demonstrated increased external rotation ROM and decreased internal rotation ROM and posterior shoulder flexibility than the nonimpaired subjects. Loss of internal rotation ROM has been thought to be an adaptive change related to posterior shoulder tightness, and stretching has been advocated.\textsuperscript{15,17,18,30} To our knowledge, the results of our study are the first to objectively measure and document the relationship between the decreased internal rotation ROM and posterior shoulder tightness found in pitchers. Based on our correlation analysis, a clinician using this measurement can expect that for ev-
ery 4° of internal rotation ROM lost, posterior shoulder tightness will increase 1 cm. The role that stretching the posterior shoulder structures plays in returning internal rotation ROM has yet to be determined.

Longitudinal measurements are important to further validate the clinical use of this measurement. Specifically, the relationship between posterior shoulder tightness and dysfunction has long been recognized clinically but has yet to be empirically quantified. Perhaps the ability to quantify shoulder tightness offered by this technique will provide further insight into pathologies and the utilities of therapeutic modalities and exercises.

**CONCLUSION**

This study presented a new objective method of measuring the flexibility of the posterior shoulder tissues and assessed construct validity of the measurement in habitual throwers. The intratester reliability of the measurement was found to be high in dominant (ICC = 0.92) and nondominant shoulders (ICC = 0.95). Intertester reliability was good (ICC = 0.80). Pitchers were found to have significantly reduced internal rotation and increased external rotation ROM compared to nonimpaired subjects. Pitchers were also found to have significantly greater posterior shoulder tightness compared to nonimpaired subjects. Posterior shoulder tightness seen in pitchers showed a significant correlation to the loss of internal rotation ROM. The findings show that our new measurement of posterior shoulder tightness is objective and reliable, particularly when made by the same physical therapist.

**ACKNOWLEDGMENTS**

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We compliment the authors on their well-designed clinical research study. They have introduced a new clinically applicable method to measure and analyze the complex problem of posterior shoulder tightness. This loss of range of motion and flexibility is common in athletes who use overhead motions (especially throwers), but also occurs frequently in nonathletes who sit at a desk or use a word processor for long periods. The operational definitions used in this commentary indicate that limited range of motion involves mostly the noncontractile tissue. Loss of flexibility implies that range of motion is limited more by the contractile units (muscle-tendinous unit). Composite interaction of various structures probably often limits the motion. However, by appropriately positioning the joint being tested or the adjacent joint (particularly, for example, with a biarticular muscle), one can change the selective tissue tension on one or the other structure to try to differentiate the “primary” limiting factor. The identification of this posterior shoulder tightness is extremely important in rehabilitating the shoulder complex because of the consequences of limited posterior capsular excursion documented experimentally.

Tyler et al state that the proposed method is easy to perform on many patients and requires no additional expensive equipment. However, we have tried this technique numerous times over the last few weeks and have identified the following limitations:

1. The isolation procedure to prevent the scapular motion is, in fact, a palpation method with inherent limitations based on the clinician’s palpation skills.
2. The authors used a manual stabilization procedure to prevent scapular motion. They state that the test is aborted if stabilization is not effective. It would be interesting to know what percentage of subjects or patients the authors were unable to stabilize adequately to perform a reliable test.
3. Many patients, particularly those who have an acute condition of the shoulder or a painful shoulder, have difficulty relaxing or being comfortable in the side-lying position. Once again, the authors say that the test is aborted if the patient cannot relax to perform the test. Knowing what percentage of subjects or patients who were unable to relax sufficiently to perform the test would be useful. One of the commentators, Mr. Wilk, indicated that approximately 20 of the patients on whom he performed the test had difficulty relaxing enough to perform the test adequately.
4. Multiple examiners are needed to perform the test and document the results.
5. Because we found it difficult to use a tape measure when performing this technique, we recommend that the clinician use a wooden ruler or carpenter’s square.
6. The clinician may have difficulty palpating and stabilizing the lateral border of the scapula in many patients with obesity or extreme hypertrophy of the posterior lateral shoulder complex muscles, such as latissimus dorsi or teres major.
7. Although intratester reliability was 0.92 and 0.95 when the same examiner measured posterior tightness, we do not know how many practice repetitions the examiner performed clinically before the reliability testing was actually performed. There is a difference between leaning a motor skill when a person starts to perform a test and when the same person has performed the test many times. It would be of interest to know the number of repetitions that each of the 2 testers performed regarding the intertester reliability.
8. The position of the scapula in the side-lying position causes the scapula to “fully retract,” which by the nature of the retraction increases the tension on the posterior structures. This may influence whether the tightness is actually in the posterior shoulder or perhaps is simply caused by the scapular retracted position.
9. Did the authors consider the amount of scapular retraction needed to determine the differences between patients with hypomobile versus hypermobile scapulae? Which position influences the tension on the positions of the posterior shoulder structures? In other words, was the position of the “fully retracted” scapula standardized? If serial measurements are taken and the position changes during rehabilitation intervention, then the starting position changes and the starting test position of the scapula does not have reliability.
10. The examiners were interested in testing this method of measuring posterior shoulder tightness in baseball players. It is interesting that the position for stabilization of the scapula in retraction is the least functional position when tightness in the posterior capsule is a clinical problem. Posterior shoulder tightness is a clinical
problem in the eccentric deceleration position, which occurs during the follow-through phase of throwing. This phase consists of glenohumeral extension, horizontal adduction, internal rotation, and scapulothoracic protraction. Therefore, because of specificity of performance, does the "fully retracted scapular position" really evaluate clinically relevant posterior shoulder tightness when the scapula is usually in the fully protracted position?

We feel that the technique is an enhancement of the supine horizontal adduction test described by Warner et al. The authors emphasize the importance of stabilizing the scapula with this method, which appears to be essential to obtaining a reliable and valid determination of posterior range of motion and flexibility. The obvious advantage of this technique is palpating and grasping the lateral border of the scapula to determine the "exact" point of movement to block the accessory scapulothoracic motion. Scapular stabilization appears to be a necessary component of reliable and meaningful clinical measures of the glenohumeral (GH) joint. Proper positioning of the upper extremity and torso to prevent spinal rotation and scapular protraction during the horizontal flexion component of motion is also mentioned by Tyler et al and appears to be the only other compensating movement that could negatively affect the integrity of the measurement.

In addition to being a new clinical method to measure posterior shoulder range of motion and flexibility, the identification of a significant correlation between posterior shoulder tightness and internal rotation range of motion limitations at 90 degrees of abduction is of particular clinical relevance. Although this relationship has been previously postulated, it has not been experimentally confirmed. As Tyler et al described it, they were also interested in assessing the "construct validity" of this measure.

The clinician's ability to objectively measure and identify range of motion restrictions is important to a successful and scientifically based shoulder treatment program. In addition to the 2 tests (GH goniometric measurements and the palpation technique for the posterior shoulder tightness test), we recommend that other tests be performed to attempt to also identify the cause of the "tightness" in the posterior structures. Although the investigators have documented a relationship between their method of assessing posterior shoulder tightness and decreased internal rotation, we recommend several tests not only to document that a limitation exists, but also to try to identify the limiting factors that will help design the treatment plan. To simply identify that limitations exist and not to know the cause of the limitations will not help treat the problem. Therefore other tests, such as the posterior load and shift (posterolateral load and shift) in several positions of abduction and scaption should be performed because the posterior muscles are relaxed and in a "neutral" position on the physiologic length-tension curve. This selectively stresses the posterior noncontractile structures. The purpose of this test is to try to either implicate the posterior noncontractile structures or rule them out as being a limiting factor to glenohumeral internal rotation.

We also recommend measuring joint range of motion with the goniometer. We think that the GH internal rotation range of motion measurement should be performed as an isolated measurement of scapulothoracic protraction. In addition, a composite measurement of glenohumeral and scapulothoracic protraction should be taken. In most books that provide descriptive normative data for the goniometric measurements for internal rotation of the GH joint, the numbers are usually greater than 45 degrees, which we feel is a composite measurement. As an example, Figure 6 in Tyler et al shows that with the internal rotation range of motion measurements, all the subjects have motions greater than 50 degrees and as high as 70 degrees. Although the patient is in the supine position and body weight stabilizes the scapula, the entire shoulder complex usually elevates off the table as the greater tuberosity engages the coracoid arch. This is the method described in the article by the Tyler et al. Therefore, this goniometric measurement does not measure GH internal rotation with true isolation of the posterior shoulder structures. Palpation or stabilization of the anterior edge of the acromion process can help avoid the anterior motion of the scapula off the table. After the isolated true GH motion is taken, then we do think it is also appropriate to perform the composite measurement for internal rotation of the GH joint and the scapulothoracic motion.

We would like to provide an example of how to treat the patient with posterior "tightness." If the posterior load and shift test is performed in various positions (0, 45, and 90 degrees) and has normal posterior translation or laxity compared to the opposite shoulder and compared to the examiner's experience relative to the normal laxity, then the noncontractile structures are not a limiting factor. If the patient has decreased isolated GH internal rotation, then the limiting factor is probably the contractile unit. Limitations caused by muscle tendon unit or flexibility deficits can be treated with a variety of methods including flexibility and stretching techniques. Bandy et al have described specific methods regarding time, repetitions, sets, etc. for increasing the muscle tendon flexibility.

On the other hand, if the patient has a decreased load and shift test in different positions (because of the load-sharing response and selective tightening of the capsule in different positions), and if they have
decreased range of motion on GH internal rotation goniometry or the test position described in this article, then it may be a combination of both contractile and noncontractile structures limiting the range of motion and flexibility. Although several flexibility tests assess the posterior GH contractile units (primarily the infraspinatus, teres minor, posterior deltoid), no consensus exists in the literature that the contractile unit can really be isolated from the noncontractile structures. Obviously, with this theoretic patient example, both the contractile and noncontractile structures need to be addressed as the limiting factors. McClure et al. have described specific "TERT formulas" (Total End Range Time) of stretching to create plastic deformation of the noncontractile unit.

We recommend that physiologic stretching techniques consist of internal rotation at 90 degrees of abduction, using static stretching described by Bandy et al. or PNF contract relax methods to try to focus more on the contractile units. The other physiologic stretch that we commonly use is the supine horizontal adduction (which allows body weight to help stabilize the scapula) along with stabilization to the lateral border of the scapula. While performing these 2 stretches, individuals often have reported that they feel a stretch in different positions. During the internal rotation stretch at 90 degrees abduction, patients often report an isolated stretch at the posterior aspect of the shoulder on the infraspinatus and deep to the muscle. However, when performing the supine horizontal adduction stretch, patients often report a diffuse feeling of stretching over the entire posterior shoulder and extending over the scapular region.

We thank the Journal for the opportunity to comment on this excellent clinical article. We also congratulate the authors on their work and encourage them to continue their research to—

(1) identify which tissues are the primary restraints and the limiting factors to each assessment technique (this would help identify the cause of the problem so it could be treated more effectively).

(2) use this new test of assessing posterior shoulder tightness in patients with various shoulder pathologies, such as those with the various impingement syndromes and GH joint instability and investigate whether there are relationships between posterior shoulder tightness and specific pathologies.

(3) use this method in postsurgical outcomes research to further determine its "construct validity."

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REFERENCES


Author Response

We greatly appreciate the thoughtful commentary of Mr. Davies, Mr. Wilk, and Mr. Ellenbecker. The foundation on which we treat patients with shoulder pathology has been laid down in part by the work of these 3 researchers. The issues they raised about our study demonstrate the need for further work in this area and provides guidelines for future studies using this new measurement technique. In our initial study, we provide the first documentation of a reliable and valid method of measuring posterior shoulder tightness.

In the clinic we are constantly being challenged to provide treatment that is evidence-based. We are limited, however, by what we are able to measure. The importance of identifying posterior shoulder tightness is recognized by the commentators and has been recognized previously by Mr. Wilk. We did not intend to convey and do not state that the measurement is easy to perform on many patients. Few clinical measurements are easily performed without practice.

An area of concern seems to be the ability of the tester to palpate and stabilize the scapula during the measurement. We recognize that the inability to do this could be a potential source of error, as in the case of many clinical tests. Accurate joint palpation and stabilization are essential for other manual skills such as peripheral joint mobilization, special tests, and goniometric measurement of the shoulder. Scapular stabilization will also be more difficult with larger patients in a way that is similar to the increased difficulty encountered when performing the load and shift test on a large patient. Unfortunately, we are unable to provide an exact percentage of instances in which stabilization was not adequate to perform a reliable test. However, we recall that we encountered a few subjects on whom it was difficult to get adequate scapular stabilization. The data on these subjects were included in our analysis and may represent the main source of error seen within and between testers.

The comments of Davies, Wilk, and Ellenbecker regarding use of this measurement on patients with shoulder pathology raise excellent points for discussion. Since the population tested in this study had no shoulder pathology or surgery, we can only speculate on what the potential limitations might be. Recently, we have started to collect data on patients with the diagnosis of secondary shoulder impingement. Because the measurement is taken below 90° of flexion, we haven’t had a problem with pain limiting the testing of an involved upper extremity. However, we have had to reposition the involved extremity in a nonpainful position when testing the uninvolved extremity.

We acknowledge that the need for 2 examiners to complete the test is a limitation. However, the recorder putting a mark on the carpenter’s square where the epicondyle is marked does not need to be a skilled clinician. We also attempted to use a tape measure at first; the comment that this procedure is difficult to use is well-taken. We designed the study using the carpenter’s square in order to avoid using a tape measure.

We are in total agreement with the commentators that a difference exists between learning a motor skill when a person starts to perform a test and when the same person has performed the test many times. The 2 testers in this study performed the test approximately 50 times each before data collection began. Error estimates between novice and expert testers are known to exist and may be present for the measurement of posterior shoulder tightness as well.

Several questions also relate to the position of the scapular at the start of the measurement. To clarify, the term “fully retracted” refers to the position of the scapula when the arm is brought passively to a position of 90° abduction each time the measurement is performed. It is at this point that the scapular is stabilized and the arm is passively moved into horizontal adduction. Indeed this position would place tension on the posterior capsule but not to the degree that was seen by O’Brien et al when a posterior force was applied. This is our only reference that documents positions influencing tension on the posterior shoulder structures. It is our opinion that the starting position of the scapular may be influenced more by the extensibility of the inferior pouch than the posterior capsule. Subjects with greater extensibility of the inferior pouch may cause the inferior angle of the scapular to retract. We did not look at differences between patients with hypomobile versus hypermobile scapulae. This was beyond the scope of this study, and we are unaware of a clinical method to objectively quantify scapular mobility. Further research may include measuring the distance from the spine to the lateral border of the scapular with roentgenograms during the posterior shoulder tightness measurement.
We were interested in testing baseball pitchers because of the documented loss of internal rotation range of motion in the dominant arm. Therefore, we could test the construct validity of our measurement technique by demonstrating the association between the loss of internal rotation range of motion and the increase in posterior shoulder tightness. We concur that the measurement is not made in a functional position. Often as clinicians we break a functional movement down into its component parts to determine where the limitation exists. This measurement of posterior shoulder tightness is only a part of the evaluation, as noted by the commentators. How much posterior shoulder tightness and the exact position of the shoulder during the throwing motion that might cause a clinical problem is unknown. We agree with the commentators that in the deceleration phase of throwing, posterior shoulder tightness may create a problem. In addition, we feel that a more precarious position for the throwing shoulder with posterior capsule tightness could be when the shoulder is in 90° abduction in the late cocking phase and the capsule is fully wound. It is in this position that the tightened posterior capsule could force the humeral head to migrate anteriorly and superiorly into the subacromial arch. This undesired translation could contribute to secondary shoulder impingement.

We agree with the view of the commentators that other tests should be performed in an attempt to identify the cause of the "tightness." The tests they recommend are extremely useful, and we also use them. Despite our use of these tests, we must caution the clinician to use care with the load and shift test to determine posterior tightness in a population without glenohumeral joint laxity. The load and shift test was described to determine anterior and posterior laxity, not tightness. The grading system of 0 to 3+ commonly used to quantify the load and shift test refers only to the amount of laxity and does not grade tightness. Actually, this was our motive behind attempting to develop a measurement of posterior shoulder tightness. As suggested, the measurement of internal rotation motion alone is not enough. Based on the circle concept, if anterior capsule tightness is present, the subject will still suffer a loss of internal rotation, as the capsule winds upon itself. The ability to control rotation during a measurement of posterior shoulder tightness seems to be important. By putting the posterior capsule in a direct line of pull, keeping the rotation neutral, and getting a capsular end-feel, we feel confident that the posterior capsule is the primary restraint to additional adduction.

As physical therapists who provide treatment to athletes who use throwing methods in competition and patients with secondary shoulder impingements, we often stretch the patient's posterior capsule. We treat a patient with posterior "tightness" similar to the example given by the authors, but how do you know if your intervention made a change over time if you do not have the ability to measure it? We feel we have developed and documented a valid, reliable, objective, and clinically applicable measurement for determining posterior shoulder tightness.

Again, we would like to thank Mr. Davies, Mr. Wilk, and Mr. Ellenbecker for their constructive review of our research report. We also thank Dr. Di Fabio, Editor-in-Chief of the Journal, for the opportunity to respond to and elaborate on this topic.

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REFERENCES