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Reliability of Shoulder Internal Rotation Passive Range of Motion Measurements in the Supine Versus Sidelying Position

• **STUDY DESIGN:** Clinical measurement, reliability.

• **OBJECTIVE:** To compare intrarater and interrater reliability of shoulder internal rotation (IR) passive range of motion measurements utilizing a standard supine position and a sidelying position.

• **BACKGROUND:** Glenohumeral IR range of motion deficits are often noted in patients with shoulder pathology. Excellent intrarater reliability has been found when measuring this motion. However, interrater reliability has been reported as poor to fair. Some clinicians currently use a sidelying position for IR stretching with patients who have shoulder pathology. However, no objective data exist for IR passive range of motion measured in this sidelying position, either in terms of reliability or normative values.

• **METHODS:** Seventy subjects (mean age, 36.8 years), with (n = 19) and without (n = 51) shoulder pathology, were included in this study. Shoulder IR passive range of motion of the dominant shoulder or involved shoulder was measured by 2 investigators in 2 positions: (1) a standard supine position, with the shoulder at 90°of abduction, and (2) in sidelying on the tested side, with the shoulder flexed to 90°.

• **RESULTS:** Intrarater reliability for supine measurements was good to excellent ($ICC_{3,1}$ = 0.70-0.93) and for sidelying measurements was excellent ($ICC_{3,1}$ = 0.94-0.98). Interrater reliability was fair to good for the supine measurement ($ICC_{2,2}$ = 0.74-0.81) and good to excellent for the sidelying measurement ($ICC_{2,2}$ = 0.88-0.96). The mean (range) value of the dominant shoulder sidelying IR passive range of motion was 40° (11° to 69°) for healthy subjects and 25° (–16° to 49°) for subjects with shoulder pathology.

• **CONCLUSIONS:** For subjects with shoulder pathology, measurements of shoulder IR made in the sidelying position had superior intrarater and interrater reliability compared to those in the standard supine position. *J Orthop Sports Phys Ther 2010;40(9):589-594. doi:10.2519/jospt.2010.3197*

• **KEY WORDS:** *glenohumeral joint, goniometry, motion, rehabilitation*

Shoulder pain is one of the most common musculoskeletal complaints seen in primary care practice.[21,24] Shoulder pathology has been associated with limitations in shoulder range of motion (ROM), specifically glenohumeral internal rotation (IR).[9,10,33,37,42] Furthermore, posterior glenohumeral soft tissue tightness has been identified as a cause of restricted glenohumeral IR.[7,13,14,18,23,25,27,30,33,37,39,42] Thus assessment of IR ROM is a critical part of orthopaedic shoulder examination. Assessment of glenohumeral IR ROM has historically been performed in the supine position. However, interrater reliability for measuring shoulder IR in this position has been reported as poor.[34] Riddle et al[34] suggest that a lack of uniform scapular stabilization by testers may lead to this poor interrater reliability. While several other methods have been developed for measuring shoulder IR or posterior shoulder tightness,[1,3,11,24,30,38] they require 2 clinicians to obtain the measurement[30,38] or have equally poor interrater reliability, or do not accurately measure shoulder IR.[1,3,11,15,24]

Due to the influence of tightness of the posterior glenohumeral soft tissues on glenohumeral IR[7,13,14,18,27,30,33,37,39,42] and shoulder kinematics,[5,14,16,17,20,23,27,29,30,35,40] stretching of the posterior glenohumeral tissues to restore glenohumeral IR ROM is a common aspect of shoulder rehabilitation. Furthermore, limitations in glenohumeral IR and posterior glenohumeral soft tissue flexibility have been identified as contributing factors in common pathologies such as shoulder impingement and instability.[14,29,36,40,41] The posterior glenohumeral soft tissues may be stretched with the "sleeper stretch," in which the patient is in sidelying to stabilize the scapula, with the arm flexed to 90° with humeral IR.[8,19] This sidelying position appears to provide more consistent scapular stabilization than a supine position for measuring shoulder IR, and

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may result in improved reliability for measuring shoulder IR.

Given the poor interrater reliability of measuring shoulder IR in the supine position, the primary purpose of this study was to compare reliability for measuring shoulder IR ROM between an alternate sidelying position and the standard supine test positions. Our hypothesis was that interrater and intrarater reliability would be higher for shoulder IR measured in the sidelying position as compared to the traditional supine position. A secondary purpose of this study was to provide descriptive data for IR passive range of motion (PROM) for healthy subjects, obtained in 2 positions.

METHODS

Subjects

The subjects without shoulder pathology, referred to as the healthy group in this manuscript, were recruited from physical therapist education programs by word of mouth and through fliers. Inclusion criteria were that the subject had to be at least 18 years of age and have no prior history of shoulder injury that required medical attention. Exclusion criteria for this study included pregnancy, an inability to tolerate testing positions, or an inability to understand the informed consent process. Fifty-three subjects without shoulder pathology volunteered for the study. One subject was unable to achieve either test position due to limitations in shoulder PROM. The data from another subject were lost. Subsequently, the data from 51 subjects (21 female, 30 male) were used for analysis. The subjects were from 18 to 50 years of age, with a mean ± SD age of 29.5 ± 7.6 years. The dominant shoulder, defined as the self-reported upper extremity that would be used to throw a ball, was measured, resulting in 47 right shoulders and 4 left shoulders being tested.

For the group with shoulder pathology, subjects were identified upon presentation to their physician appointment for a shoulder injury/pathology. They were not under the care of either of the raters. Inclusion criteria were that the subject was 18 years of age or older and was seeking medical attention for a current shoulder injury/pathology. All exclusion criteria were identical for these subjects. In addition, subjects in this group were also excluded if they had any history of glenohumeral dislocation, subluxation, or humeral fracture. Twenty-one subjects with shoulder pathology volunteered to participate in the study. One subject was unable to achieve the sidelying position due to having less than 90° of shoulder flexion PROM, and 1 subject was limited by pain so that a consistent end feel could not be obtained in either the sidelying or supine test position. Subsequently, data from 19 subjects with shoulder pathology (10 male, 9 female) were used for analysis. The subjects ranged in age from 27 to 75 years, with a mean ± SD age of 52.9 ± 14.6 years. This group included subjects with shoulder impingement syndrome (n = 6), rotator cuff repair (n = 6), total shoulder arthroplasty (n = 3), adhesive capsulitis (n = 2), nonoperative superior labrum anterior to posterior tear (n = 1), and subacromial decompression (n = 1). The involved side of subjects with shoulder pathology was measured, resulting in 13 right shoulders and 6 left shoulders being tested.

This study was approved by The Institutional Review Boards at the University of Minnesota and St Catherine University. All subjects read and signed a consent form before admission into the study. The rights of the subjects were protected.

Raters

Measurements were taken by 2 physical therapists. Rater 1 (M.D.M.) had 5 years of clinical experience and rater 2 (C.J.C.) had 9 years of clinical and teaching experience.

Procedures

Each rater obtained 2 PROM measurements of shoulder IR in the 2 testing positions, supine and sidelying, all within the same testing session. The order of the raters and the order of the testing positions were randomized for each subject prior to data collection. Subjects were not allowed to warm up prior to testing.

FIGURE 1. (A) Starting position of supine internal rotation passive range of motion measurements. (B) Ending position.

Supine measurements of shoulder IR PROM were obtained with the subject lying supine on a standard examination table, with the shoulder initially abducted to 90° with 0° rotation and the elbow flexed to 90° with neutral pronation/supination (**FIGURE 1A**). A towel roll was placed under the distal humerus, so that the humerus was level with the acromion process and the olecranon process was at the edge of the plinth. This is the standard position, as described by Norkin and White.[31] The rater stabilized the scapula with 1 hand positioned over the acromion and coracoid processes. Care was taken to avoid contacting the humeral head, thereby allowing full IR to occur at the glenohumeral joint. The rater's other hand was positioned just proximal to the subject's wrist. The humerus was then passively internally rotated while maintaining 90° of abduction and 90° of elbow flexion (**FIGURE 1B**). The amount of IR PROM was measured (in degrees) when maximal IR and a firm end feel was obtained without a loss in the amount of scapular stabiliza-

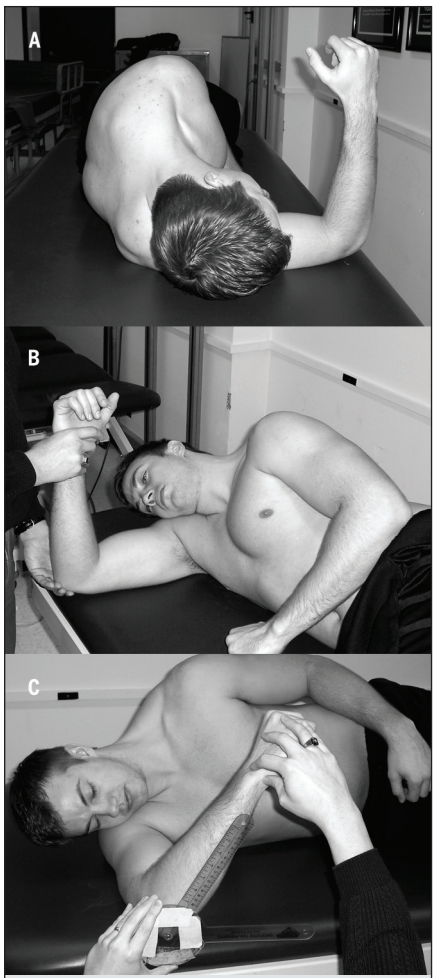

FIGURE 2. (A) Perpendicular alignment of the acromion processes in the sidelying position. (B) Starting position of sidelying internal rotation passive range of motion measurements. (C) Ending position.

tion provided by the rater.

Sidelying measurements of shoulder IR PROM were obtained with the subject lying on the dominant or involved side, in a position in which the acromion processes were aligned perpendicular to the plinth by visual estimate (**FIGURE 2A**). The shoulder was flexed to 90° with 0° rotation and the elbow was flexed to 90° (**FIGURE 2B**). Again, the olecranon process was positioned at the edge of the plinth. No manual stabilization of the scapula was required, but the rater visually ensured that the subject kept the acromion processes perpendicular to the table. The rater passively internally rotated the humerus while maintaining 90° shoulder and elbow flexion (**FIGURE 2C**). Determination of IR PROM was again based on the point of maximum IR, where a distinct, firm end feel was noted by the rater.

A research assistant, independent of the 2 raters, read the goniometer, recorded the information on the subject's data sheet, and then reset the goniometer to 0° before returning it to the rater. The procedure was repeated twice in each position then repeated in the same order by the other rater.

An international standard goniometer with a 25-cm movable arm was used in this study. The scale of the goniometer was marked in 1° increments. In both testing positions, the rater located the goniometer such that the fulcrum was placed over the olecranon process, the stationary arm was aligned with the plinth edge, and the movable arm aligned with the subject's ulnar styloid process. The goniometer was covered on 1 side with white athletic tape, such that the raters were unable to see the numeric value of the measurement.

Data Analysis

Intraclass correlation coefficients ($ICC_{3,1}$) were used to measure within-session intrarater reliability for each rater and each group of subjects for both the supine and sidelying positions. $ICC_{2,2}$ were used to calculate interrater reliability of the mean of each rater's 2 measurements taken in the supine and the sidelying position for both the healthy and shoulder pathology groups, separately. ICC values were classified for reliability, using the following criteria: excellent (0.90-0.99), good (0.80-0.89), fair (0.70-0.79), and poor ($\leq$0.69).[2]

Separate 2-way analyses of variance (ANOVAs) were calculated using the mean IR measurements to examine differences between raters and positions for each of the 2 groups (healthy and shoulder pathology).[32] The level of significance (α) for this study was set to .05. Significant interactions were investigated using post hoc pairwise comparisons.

Finally, the minimum detectable change (MDC) at the 95% level was calculated using the equation $MDC_{95} = 1.96 \times \sqrt{2} \times SEM$.[32] Descriptive data for glenohumeral IR ROM for the sidelying position of those without shoulder pathologies was determined by taking the mean of the combined data for rater 1 and rater 2. All statistical calculations were computed with SPSS Version 16.0 for Windows (SPSS Inc, Chicago, IL).

RESULTS

The ICCs for intrarater reliability for measurements of shoulder IR was equal or greater than 0.86 for both testers, both groups, and both positions, with the exception of the supine position for the group with pathology for tester 1, which was 0.70 (**TABLE 1**). The ICCs for interrater reliability in the healthy group was 0.81 (95% confidence interval [CI]: 0.66, 0.89) and 0.88 (95% CI: 0.79, 0.93) for the supine and sidelying positions, respectively (**TABLE 2**). For the group with pathology, the ICCs for interrater reliability were 0.74 (95% CI: 0.33, 0.90) and 0.96 (95% CI: 0.90, 0.98) for the supine and sidelying positions, respectively (**TABLE 2**).

TABLE 3 provides the descriptive statistics for shoulder IR ROM measured by both raters, in both groups and both testing positions. Data are derived from the average of the measurements made by the raters.

Separate, 2-way ANOVAs were performed, using rater and position as independent variables, for both the healthy and shoulder pathology groups. For the healthy group, a significant rater-by-position interaction was found ($P = .034$). Post hoc analysis indicated that there was a significant difference between testers for measurements made in the supine position ($P<.05$), but no difference in the sidelying position. Also, for both testers, there was less IR ROM when measured in the sidelying position compared to supine ($P<.01$) (**TABLE 2**).

For the group with shoulder pathology, no significant interaction was found

TABLE 1 Intrarater Reliability for Shoulder IR Range of Motion Measurements

	Group	Measurement 1 Mean ± SD	Measurement 2 Mean ± SD	$ICC_{3,1}$ (95% CI)
Rater 1				
Supine	Healthy	52.3° ± 8.3°	52.2° ± 7.5°	0.88 (0.79, 0.93)
Sidelying	Healthy	39.8° ± 9.6°	39.7° ± 9.6°	0.94 (0.90, 0.97)
Supine	Pathology	45.0° ± 10.4°	46.8° ± 10.1°	0.70 (0.37, 0.87)
Sidelying	Pathology	24.8° ± 14.4°	26.3° ± 14.2°	0.96 (0.90, 0.98)
Rater 2				
Supine	Healthy	57.7° ± 8.7°	58.0° ± 8.9°	0.86 (0.77, 0.92)
Sidelying	Healthy	38.8° ± 12.3°	40.5° ± 12.6°	0.95 (0.91, 0.97)
Supine	Pathology	50.8° ± 8.0°	49.7° ± 8.8°	0.93 (0.82, 0.97)
Sidelying	Pathology	23.9° ± 13.6°	24.2° ± 13.2°	0.98 (0.95, 0.99)

Abbreviations: CI, confidence interval; ICC, intraclass correlation coefficient; IR, internal rotation.

TABLE 2 Interrater Reliability for Shoulder IR Range of Motion Measurements

Position	Group	Rater 1 Mean ± SD	Rater 2 Mean ± SD	$ICC_{2,2}$ (95% CI)
Supine	Healthy	52.2° ± 7.6°	57.8° ± 8.5°	0.81 (0.66, 0.89)
Sidelying	Healthy	39.8° ± 9.5°	39.6° ± 12.3°	0.88 (0.79, 0.93)
Supine	Pathology	45.9° ± 10.1°	50.3° ± 7.8°	0.74 (0.33, 0.90)
Sidelying	Pathology	25.6° ± 14.3°	24.1° ± 13.3°	0.96 (0.90, 0.98)

Abbreviations: CI, confidence interval; ICC, intraclass correlation coefficient; IR, internal rotation.

TABLE 3 Descriptive Statistics for Shoulder IR Range of Motion Measurements

	Group	Mean ± SD	Range
Rater 1			
Supine	Healthy	52° ± 8°	37° to 69°
Sidelying	Healthy	40° ± 10°	21° to 61°
Supine	Pathology	46° ± 10°	13° to 58°
Sidelying	Pathology	26° ± 14°	−16° to 49°
Rater 2			
Supine	Healthy	58° ± 9°	33° to 73°
Sidelying	Healthy	40° ± 12°	11° to 69°
Supine	Pathology	50° ± 8°	38° to 69°
Sidelying	Pathology	24° ± 13°	−12° to 42°

Abbreviations: IR, internal rotation.

between rater and position; however, a significant effect of position was revealed ($P<.01$), with a lower value of IR ROM seen in the sidelying position compared to supine (**TABLE 2**).

The MDC_{95} for the supine position was 2.3° and 4.1° for the healthy group and the shoulder pathology group, respectively. The MDC_{95} for the sidelying position was 3.0° and 6.1° for the healthy group and shoulder pathology group, respectively. Sidelying IR PROM for the healthy subjects varied from 11° to 69°, with a mean value of 39.7° (**TABLE 3**).

DISCUSSION

The present study found that shoulder IR ROM measurements made in the supine position have fair to good interrater reliability (**TABLE 2**). Using a sidelying position to measure shoulder IR with a standard goniometer in healthy people and individuals with shoulder pathology, we found intrarater reliability to be excellent (**TABLE 1**) and interrater reliability to be good to excellent (**TABLE 2**). For both groups of subjects in this investigation, the interrater reliability values were higher for the sidelying position when compared to the traditional supine position. However, caution is warranted when interpreting the difference in reliability between positions, as some of the 95% CIs overlap (**TABLES 1** and **2**). The 2-way ANOVAs for the healthy group indicate that there was no difference in shoulder IR ROM measures between raters for the sidelying position, but there was a difference between raters for the supine position.

Due to the amount of variability between raters in measuring shoulder IR ROM in a supine position, several attempts have been made to measure shoulder IR ROM in different positions. The use of maximum vertebral level reached by a patient's thumb is a common clinical practice. Tomographic scans have shown that this motion requires scapular anterior tipping and IR, glenohumeral extension and IR, and elbow flexion.[24] Furthermore, interrater reliability was shown to be poor for measuring shoulder IR by vertebral level.[11,15] Tyler et al[38] found high intrarater (ICC = 0.92-0.95) and good interrater (ICC = 0.80) reliability with a posterior capsule measurement technique performed in sidelying on the nontested side. In our clinical practice, we have found this technique of measuring IR PROM to be difficult to administer, in part due to quantifying the amount of restriction based on distance from the plinth rather than degrees, the need for 2 clinicians to perform the test, and the difficulty in stabilizing the scapula.

Riddle et al[34] attributed the poor interrater reliability of IR measurements made

in the supine position to a lack of uniform scapular stabilization by the testers. The accessory scapular motion of anterior tipping has been described by several authors as occurring during shoulder IR motion.[9,22,28,31] If this accessory motion can be minimized by improved stabilization techniques, the IR measurement is better isolated to the glenohumeral joint. Ellenbecker[12] suggested manually stabilizing the scapula at the coracoid process, with the patient in the traditional supine position.[12] However, this method has been shown to have poor interrater reliability for shoulder IR PROM.[1,3] The authors of the current study believe that the sidelying position on the tested side facilitates improved scapular control by weight bearing on the scapula, thus minimizing the accessory scapular movement of anterior tipping. Within the same subject, the sidelying position provides for a consistent amount of weight bearing on the scapula, independent of any stabilization by the examiner. Therefore, in the sidelying position there is a uniform amount of stabilization between examiners within the same subject, and we have found that this yields a more distinct, firm end feel. In contrast, the amount of stabilization of the scapula through the acromion and coracoid process may not be consistent between examiners when the measurements are performed in the supine position. These factors likely contributed to the improved interrater reliability of the sidelying position as measured in the current study.

It is our supposition that the sidelying position, which places the shoulder in combined flexion, horizontal adduction, and IR, may produce more tension in the posterior glenohumeral soft tissues than the supine position.[35] The sidelying position used in this investigation is identical to the position used to stretch the posterior glenohumeral soft tissues with the "sleeper stretch." The sleeper stretch has been shown to yield acute increases in shoulder IR ROM.[19]

The average sidelying IR PROM value in healthy subjects in our study was approximately 40°. This sidelying value of 40° is greatly different than the American Academy of Orthopedic Surgeons normative value of 70° for IR in a supine position.[31] The average sidelying IR PROM value for subjects with shoulder pathology was approximately 25°, which is significantly lower than the value obtained for healthy subjects. The improved scapular control in the sidelying position, along with a greater isolation of the posterior glenohumeral soft tissues, may account for the lower IR PROM values obtained in this study.

Our average supine IR PROM value was 55°, which is well below the American Academy of Orthopedic Surgeons normative value for IR. We believe the lower IR values obtained in the standard supine position was due to more consistent scapular stabilization between raters, as well as clear methodology for determination of end feel. The interrater reliability in our supine position was lower than that obtained in the sidelying position. This finding indicates that measurement of shoulder IR in the supine position has inherent limitations due to inconsistent stabilization, while the use of the sidelying position may minimize this issue.

The MDC_{95} values for this study ranged between 2.3° and 6.1° (by position and group), which is comparable to previous literature[4,6] in regard to the variability of 4° to 5° associated with goniometric measurements of the extremities. However, the MDC_{95} values in the sidelying position are higher than those in the supine position, indicating greater variability within the sidelying position. This variability is also seen when looking at the standard deviations of mean shoulder IR values between each position, irrespective of group (**TABLE 3**). This may seem contradictory in light of the higher ICC values for measuring shoulder IR in the sidelying position regardless of group.

Limitations of our study include a relatively small sample size, a relatively young population, and the use of only 2 raters. Furthermore, the group with shoulder pathology consisted of subjects that were generally older, which might have influenced the between-group differences for mean shoulder IR ROM. In addition, some subjects were unable to achieve the supine or sidelying test positions due to pain or restrictions in shoulder IR ROM. However, this was a very small percentage (1% and 3%, respectively). The vast majority of the subjects were able to tolerate the sidelying position without lasting provocation of symptoms, while having a very distinct, firm end feel, as opposed to an empty end feel secondary to pain. A semisidelying position, which would be between the 2 test positions utilized in this investigation, may allow for decreased pain for the patient while maintaining adequate scapular stabilization; but it also may result in increased variability in IR ROM values between examiners. Thus, we still advocate the continued investigation into the use of the sidelying position for measuring shoulder IR, due to its better reliability, even though this testing position may be painful in a small percentage of individuals.

CONCLUSION

Sidelying IR PROM measurement of the shoulder had overall greater intrarater and interrater reliability than the traditional supine measurement. The average value of sidelying IR PROM was 39.7° for healthy subjects and 24.8° for subjects with shoulder pathology. ◉

KEY POINTS

FINDINGS: Measurements of shoulder IR performed in a sidelying position resulted in overall better reliability than measurements made in a supine position. The average amount of IR in the sidelying position for healthy subjects was 39.7° (range, 11°-69°).

IMPLICATION: Measuring shoulder IR PROM in a sidelying position should be considered.

CAUTION: This study had a relatively small sample size and compared measures between only 2 raters.

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