IJSPT

ORIGINAL RESEARCH

RELIABILITY OF THE SITTING HAND PRESS-UP TEST FOR IDENTIFYING AND QUANTIFYING THE LEVEL OF SCAPULAR MEDIAL BORDER POSTERIOR DISPLACEMENT IN OVERHEAD ATHLETES

Junggi Hong, PhD, ATC[1]
Meredith J. Barnes[1]
Charles E. Leddon, MS, ATC[2]
Guido Van Ryssegem, MS, ATC, CSCS, RN[2]
Benjamin Alamar, PhD[3]

ABSTRACT

Background: The lack of proper scapular kinematics can limit the function of the entire shoulder complex.[1,3] Many forms of scapular dyskinesis have been proposed along with tests to measure for the position and motion associated with those positional and movement faults (2,4-6). While scapular internal rotation has been listed among the forms of scapular dyskinesis there has not been a reliable test documented in the literature that examines this motion. The purpose of this study was to determine whether an innovative scapular medial border posterior displacement measurement device has adequate inter-rater and intra-rater reliability when used at rest and during the sitting hand press up test.

Methods: 16 male Division III baseball players free of upper limb injury for the previous 12 months participated in the study. Posterior scapular displacement measures were taken on each subject in a resting static posture and while performing a sitting hand press up test. Subjects were tested twice within 24 hours by two separate examiners. Intraclass correlation coefficients (ICC) were calculated to determine intra-rater and inter-rater reliability.

Results: The intra-rater reliability for rater 1 was .97 (95% confidence interval [CI] = .91-.98), for the rest position and .95 (95% CI = .86-.98) for the sitting hand press-up position. Intra-rater reliability for rater 2 was .99 (95% CI = .97-.99) for the rest position and .98 (95% CI = . 95-.99) for the sitting hand press-up position. The ICCs for inter-rater reliability of the scapular medial border posterior displacement measurement in at the rest position and the sitting hand press-up position were .89 (95% CI = .81-.96) and .89 (95% CI = .80-.96) respectively.

Conclusions: The findings of this study indicate that the measurement of medial border posterior displacement using this device demonstrates good to excellent inter-rater and intra-rater reliability.

Key Words: reliability, scapular dyskinesis, sitting hand press up test

[1] Willamette University, Salem, OR, USA
[2] Oregon State University, Corvallis, OR, USA
[3] Menlo College, Atherton, CA, USA

No funding was granted for the study.

Acknowledgement

The authors would like to thank the Willamette University Department of Athletics as well as Peter Harmer, Ph.D at Willamette University for his contribution to the design of the study.

CORRESPONDING AUTHOR

Junggi Hong, PhD, ATC
Department of Exercise Science,
Willamette University
900 State Street, Salem OR 97301

INTRODUCTION

Proper alignment and motion of scapula are important to the function of the glenohumeral joint for two reasons. First, the position of scapula on the thorax aligns the glenoid with the humerus to allow for smooth movement in multiple planes of motion. Second, the scapula is the origin of the rotator cuff muscles, which provide dynamic stability to the joint by compressing the head of the humerus into the glenoid. Without proper alignment the rotator cuff muscles would be at a disadvantage due to changes in their length-tension ratio as well as their angles of pull.[1,5] Movement of the scapula is complex. It is comprised of three rotations-upward/downward rotation which occurs around a horizontal axis perpendicular to the plane of scapula, internal/external rotation which occurs around a vertical axis in the plane of the scapula, and anterior/posterior tilt, which is a rotation around a horizontal axis in the plane of the scapula; two translations-elevation/depression, and superior/ inferior glide; and finally, protraction/retraction, which has been described as a combination movement between and anterior/posterior glide and internal/external rotation.[1,2,7,8] An example of this coordinated movement can be observed during humeral elevation when the scapula moves into upward rotation, which when combined with the 2 to 1 ratio of movement with the glenohumeral joint allows for full overhead motion. Concurrently, the scapula posteriorly tilts raising the acromion to prevent impingement, and externally rotates to allow the head of the humerus to rotate on the center of the glenoid as it progresses through the full range of motion.

In recent years, there has been a great deal of research that has focused on alterations in normal scapular positioning and movement. These alterations known as scapular dyskinesis have been linked to many glenohumeral joint injuries such as impingement syndrome, labral damage, and rotator cuff tears in overhead athletes.[1,2,7,9-12] These conditions can be caused by a loss of upward rotation, an increase in internal rotation, an increase in protraction, or an increase in anterior tilt which together or separately can affect the subacromial functional space leading to glenohumeral pathologies.[1,10-12] These changes in scapular motion have been linked to muscular tightness, fatigue, and weakness of the scapular positioning muscles that include the rhomboids, serratus anterior, lower trapezius, middle trapezius, upper trapezius, and pectoralis minor.[2,3,8,13] While a limitation in any one of the scapular movements can put the shoulder at risk for injury, Kibler et al.[7] described three types of scapular dyskinesis that put shoulders at risk: Type I, which is characterized by an inferior medial border prominence, Type II that is characterized by a medial border prominence, and Type III characterized by a superior medial border prominence. All three of these dysfunctions highlight alterations in the rotational position of scapula. Warner et al.[9] found that 54% of subacromial impingement patients had an increase in medial scapular border prominence.

Subjective scapular posture and movement analysis have been part of clinician's shoulder evaluations for quite some time, however, recently, objective measures have been developed to assist in accurate diagnosis and with pre-injury screening. The lateral scapular slide test looks at the amount of protraction by measuring the distance from the midline to the medial border of scapula.[10] Inclinometers have been used aligned with the spine of scapula to measure upward and downward rotation.[4] There are also clinical tests that seek to eliminate symptoms by providing manual corrections to the scapular dysfunction such as the scapular reposition test, modified scapular assistance test, and the scapular retraction test.[5,12] Some believe that these evaluations are limited by the lack of muscular activity during their performance, in contrast to the increased medial scapular prominence one might see when a subject does a push-up against a wall, or the change in rotator cuff strength during testing when the scapula is in different positions.[3,5,6] There are also evaluations that require expensive equipment like an EMG unit that measures the timing of the scapular muscle activation, or 3-D motion capture analysis systems that evaluate the movement of the scapula, but are still not capable of capturing the motion of the scapula during highly dynamic activities like throwing.[8,10,14] With the current measures that are available, the average clinician still lacks an affordable way to evaluate the one motion that may have a significant impact on shoulder injuries in the overhead athlete, medial border prominence or more accurately scapular internal rotation.

The device used in this study was designed to measure the distance from the rib cage to the medial border of the scapula while at rest, as well as when the scapular

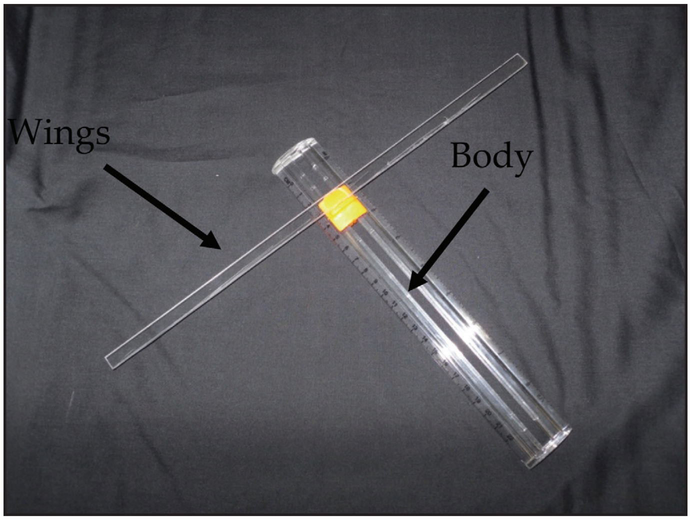

Figure 1. *Scapular Posterior Displacement Measuring Tool.*

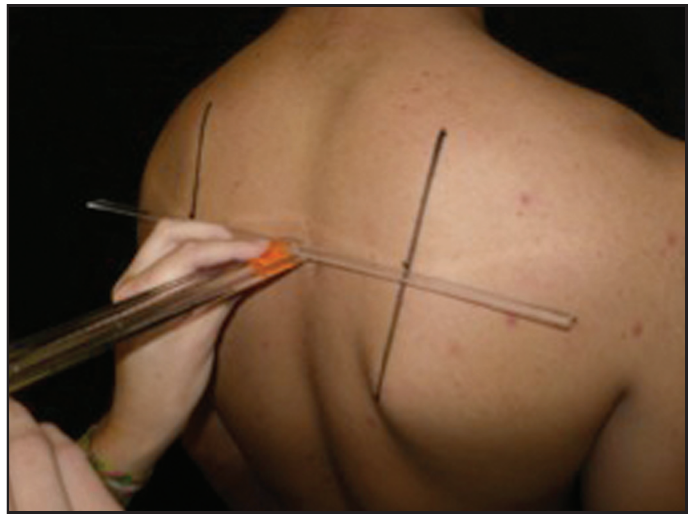

Figure 2. *Scapular medial border posterior displacement measurement in resting position.*

stabilizing muscles are placed under a load. The isometric load was imparted through the use of sitting hand press up test which involves the subject pressing down into a table or chair from the seated position and raising their body weight up for 5 seconds while a measure of the scapular medial border posterior displacement is taken. The sitting hand press up test requires extension at the shoulder, extension of the elbow, as well as flexion at the hip and knee. This position requires extreme stabilization of the shoulder girdle, particularly the scapulo-thoracic joint. The purpose of the study is to establish whether this new tool can provide a reliable means of screening for scapular medial border posterior displacement at rest and during the sitting hand press up test. It is the authors' hypothesis that the testing protocol, using the novel scapular measurement tool, will prove to be a reliable method for evaluation of scapular medial border posterior displacement.

METHODS

A total of 16 Division III male baseball players (19.5 ± 1.3 yrs, 184.9 ± 7.2 cm, 88.6 ± 10.4 kg) volunteered for the study. Exclusion was based on any history of shoulder pathology (dominant or non-dominant side), including injuries to any part of the shoulder complex, not just the glenohumeral joint. Subjects provided informed consent prior to participation, as approved by Willamette University's Institutional Review Board for the Protection of Human Subjects.

All measurements were taken with a standardized scapular medial border posterior displacement measurement tool (Figure 1) in two positions, a resting and a sitting hand press-up position. Prior to measurement, subjects were instructed: "relax and stand in your normal standing position." At this point, the length of the medial border of each scapula was determined by measuring the length of a line drawn from the superior angle to the inferior angle. A mark was then placed at the midpoint of the line to use as a reference point for placement of the measuring tool during testing. The measurement of resting position in standing was taken first (Figure 2). With the patient remaining in the relaxed standing position, the tool's wings were placed on the halfway marks, and the body of the device was moved towards the spine until it touched the subject's spinous process. The sitting hand press-up position was measured by placing two chairs with the backrests facing each other at shoulders width apart, and then prior to instructing the subject, the chairs were tested by researchers to ensure they could hold the bodyweight of the subject. Subjects were then instructed: "with one hand on the back of each chair press-up and support your bodyweight while pulling your knees up to a 90° angle and hold for five seconds." Measurements were taken in the identical manner as in the resting position (Figure 3). Values were recorded to the nearest millimeter for both positions. Testing was done on consecutive days with different examiners.

Statistical Analysis

A level of statistical significance of $p \leq 0.05$ was set for all analyses. Reliability was measured by calculating Intra Class Correlation Coefficients (ICCs).[5] ICCs were

Figure 3. *Scapular medial border posterior displacement measure during the sitting hand press-up test.*

calculated to evaluate the intra- and inter-rater reliability of the scapular medial border posterior displacement measurements. Intra-rater reliability for each rater was based on the calculation of the ICC for each individual rater. Inter-rater reliability was established by calculating the ICC for all tests performed by all raters. The ICC is an appropriate measure for both the intra- and inter-rater reliability as it considers both consistency of and absolute agreement between paired observations.[15]

Results

Statistical assumptions of the data distribution and homogeneity of variances were met for all analyses. Scapular medial border posterior displacement in a resting position and during the sitting hand press-up test was measured on all 16 subjects. The scapular medial border posterior displacement measures between the rater 1 and 2 in standing position were 1.1 ± 0.63 cm and 1.09 ± 0.60 cm vs. 1.15 ± 0.65 cm and 1.18 ± 0.61 cm for the 1st and 2nd testing sessions. The values in a sitting hand press up position between the raters were 1.36 ± 0.60 cm and 1.36 ± 0.60 cm vs. 1.31 ± 0.64 cm and 1.33 ± 0.63 cm for the 1st and 2nd measurements (Table 1). Intraclass correlation coefficients (2,1) for intra-rater reliability in the resting position were .97 (95% CI of .91 to.98) and .99 (95% CI of .97 to .99) for raters 1 and 2, respectively. ICCs for intra-rater reliability in the sitting hand press-up test were .95 (95% CI of .86 to .98) and .98 (95% CI of .95 to.99) for raters1 and 2. The ICC for inter-rater reliability was .89 (95% CI of .81 to .96) for the resting position and .88 (95% CI of .80 to .96) for the sitting hand press-up test (Table 2). The standard error of measurements (SEM) of the scapular medial border posterior displacement for the rater 1 and 2 in the resting position and the sitting hand position were 0.15 and 0.16 cm (Table 2). The SEM for the scapular medial border posterior displacement between the raters in the resting and sitting hand position were 0.16 and 0.15 cm (Table 2).

DISCUSSION

The results of the study showed that by using the method proposed, the scapular medial border posterior displacement demonstrated acceptably high clinical intra- and inter-rater reliability. Portney and Watkins[16] have suggested that ICC values above .75 are indicative of good reliability and those below .75 should be considered as poor to moderate. According to the suggestion made by the same authors, reliability of clinical measurements should exceed .90 to ensure reasonable validity.[16] All the ICC measurements in this study were close to or above .90, which

Table 1. *Mean values and standard deviations for scapular medial border posterior displacement measurements.*

Tester	Testing Position	1st measurement (cm)	2nd measurement (cm)
1	Rest	1.1±0.63	1.09±0.60
	Press up	1.36±0.60	1.36±0.60
2	Rest	1.15±0.65	1.18±0.61
	Press up	1.31±0.64	1.33±0.63

Table 2. *Intra-rater reliability of the resting and the sitting hand press-up position in determining scapular medial border posterior displacement.*

	Testing Position	Single measure ICC (2,1)	95% CI	SEM (cm)
Intra-Rater 1	Rest	0.97	.91 to .98	0.15
	Press up	0.95	.86 to .98	0.15
Intra-Rater 2	Rest	0.99	.97 to .99	0.16
	Press up	0.98	.95 to .99	0.16
Inter-Rater	Rest	0.88	.81 to .96	0.16
	Press up	0.89	.80 to .96	0.15

ICC= Intraclass correlation coefficient; CI= Confidence interval; SEM= Standard error of measurement

indicates that they have met the threshold for both good reliability and could offer clinical utility as a measurement procedure. Standard error of measurements (SEM), which is non-relative measure of reliability provides the clinician with an estimation of the error associated with a measurement in the units used to make that measurement.[17] The SEM for all measurements ranged from 1.5 mm to 1.6 mm at rest and during the sitting tests (muscles engaged) demonstrating very low measurement error.

In a clinical evaluation a clinician looks for a lifting of the medial border of the scapula away from the spine/rib cage during shoulder motion to confirm a diagnosis of scapular medial border posterior displacement. Current clinically available testing procedures quantify motion laterally away from the spine (LSST), or upward and downward rotation of the scapular but not posterior motion away from the spine.[2,10] By combining these three tests, an examiner may be able to get a more clear picture of scapular motion without the use of expensive and time consuming three-dimensional motion capture analysis. The test described in this paper measures medial border posterior displacement without the use of an expensive motion capture device. Unlike motion capture the test used in the study is still a two dimensional test which presents certain limitations in representing scapular motion, however, it was determined to be a reliable measure of medial border posterior displacement when used at the midpoint along the medial border of the scapula. This measure at this location along the medial border eliminates inconsistency in the measurement technique due to anterior and posterior tilt. It also reduces the amount of soft tissue interference in the measurement that could be influenced by muscle size differences over the superior angle.

The availability of a reliable and valid clinical method for determining the amount of scapular medial border posterior displacement in athletes would be an invaluable tool for accurate evaluation of the stabilizing structures of the shoulder.[2,18] This clinical measure would allow for pre- and post-activity measurements as well as multiple measures throughout the course of a season or throughout the progression of a rehabilitation program. In evaluating the extent of medial border posterior displacement it is important to obtain measures both at rest and with muscular activity. Currently, inexpensive and clinically feasible options such as the scapular slide test are limited to resting and semi-dynamic measures of scapular position in upward rotation. The test presented here shows significant promise for use of an inexpensive clinical device that would allow for testing of scapular internal rotation, both at rest and semi-dynamically.

A larger scale study of between examiner and between-trials reliability is warranted to better establish the reliability of this innovative method and device. Future studies should use this new method on pathological populations in order to determine if significant relationships exist between the amount of scapular medial border displacement and injuries. Ludewig and Cook, Myers et al. and Borsa et al. hypothesized that alterations in scapular position and movement may bear a direct relationship to scapular stability and the generation of muscular force production,[14,19,20] however this relationship is still poorly understood. The authors of this paper believe that it is necessary to continue research into how alterations in scapular position and motion affect neuromuscular function of the shoulder complex and how it is related to shoulder injury and dysfunction.

CONCLUSION

The raters in this study demonstrated excellent intra-rater and good inter-rater reliability when assessing scapular medial border posterior displacement with the standardized measurement tool in both static and semi-dynamic testing positions. The reliable information obtained from the sitting hand press-up test may assist in the clinical assessment and documentation of athletes' progress in the rehabilitation process, thereby enhancing rehabilitation providers' ability to effectively measure the results of, adjust, and monitor treatment outcomes.

REFERENCES

1. Borsa PA, Laudner KG, Sauers EL. Mobility and stability adaptations in the shoulder of the overhead athlete: a theoretical and evidence-based perspective. *Sports Med*. 2008;38:17-36.
2. Burkhart SS, Morgan CD, Ben Kibler W. The disabled throwing shoulder: spectrum of pathology part III: the SICK scapula, scapular dyskinesis, the kinetic chain, and rehabilitation. *J Arthro & Related Surg.* 2003;19(6):641-661.
3. Martin RM, Fish DE. Scapular winging: anatomical review, diagnosis, and treatments. *Curr Rev Musculoskelet Med*. 2007;1:1-11.
4. Laudner KG, Stanek JM, Meister K. The relationship of periscapular strength on scapular upward rotation in professional baseball pitchers. *J Sports Rehab*. 2008;17:95-105.
5. Merolla G, Santis E, Campi F, Paladini P, Porcellini G. Infraspinatus scapular retraction test: a reliable and practical method to assess infraspinatus strength in overhead athletes with scapular dyskinesis. *J Orthop Traumatol*. 2010;11:105-110.
6. Lunden JB, Braman JP, LaPrade RF, Ludewig PM. Shoulder kinematics during the wall push-up plus exercise. *J Shoulder Elbow Surg*. 2010;19:216-223.
7. Kibler WB, McMullen J. Scapular dyskinesis and its relation to shoulder pain. *J Am Aca Orthop Surg*. 2003;11:142-151.
8. Kibler WB, Sciascia AD, Uhl TL, Tambay N, Cunningham T. Electromyographic Analysis of Specific Exercises for Scapular Control in Early Phases of Shoulder Rehabilitation. *Am J Sports Med*. 2008;36:1789-1798.
9. Warner JJ ML, Arslanian LE, et al. Scapulothoracic motion in normal shoulders and shoulders with glenohumeral instability and impingement syndrome: a study using Moire topographic analysis. *Clin Orthop.* 1992;285:191-199.
10. Fortkomme B CJ, Croisier J. Scapular positioning in athlete's shoulder. *Sports Med*. 2008;38:369-386.
11. Laudner KG, Myers JB, Pasquale MR, Bradley JP, Lephart SM. Scapular dysfunction in throwers with pathologic internal impingement. *J Orthop Sports Phys Ther.* 2006;36:485-494.
12. Tate AR. Effect of the Scapula Reposition Test on Shoulder Impingement Symptoms and Elevation Strength in Overhead Athletes. *J Orthop Sports Phys Ther.* 2008;38:4-11.
13. Moraes GF FC, Teixeira-Salmela LF. Scapular muscle recruitment patterns and isokinetic strength ratios of the shoulder rotator muscles in individuals with and without impingement syndrome. *J Should Elbow Surg.* 2008;17:48S-53S.
14. Myers JB, Laudner KG, Pasquale MR, Bradley JP, Lephart SM. Scapular position and orientation in throwing athletes. *Am J Sports Med*. 2005;33:263-271.
15. T'Jonck L and Lysens R. Measurement of scapular position and rotation: a reliability study. *Physiother Res Int.* 1996;1:148–158.
16. Portney L, Watkins M. *Foundations of clinical research: Applications to practice*. Norwalk, CI: Appleton & Lange, 1993.
17. Gibson MH, Goebel VG, Jordan TM, Kegerreis S, Worrell TW. A reliability study of measurement techniques to determine static scapular position. *J Orthop Soprts Phys Ther.* 1995;21:100-106.
18. Kibler W. The role of the scapula in athletic shoulder function. *Am J Sports Med.* 1998;26:325-337.
19. Ludewig PM, Cook TM. Alterations in shoulder kinematics and associated muscle activity in people with symptoms of shoulder impingement. *Phys Ther.* 2000;80: 276-291.
20. Borsa PA, Timmons MK, Sauers EL. Scapular-positioning patterns during humeral elevation in unimpaired shoulders. *J Athl Train.* 2003; 38:12-17.