Research Report

Measurement of Scapular Asymmetry and Assessment of Shoulder Dysfunction Using the Lateral Scapular Slide Test: A Reliability and Validity Study

Background and Purpose. The Lateral Scapular Slide Test (LSST) is used to determine scapular position with the arm abducted 0, 45, and 90 degrees in the coronal plane. Assessment of scapular position is based on the derived difference measurement of bilateral scapular distances. The purpose of this study was to assess the reliability of measurements obtained using the LSST and whether they could be used to identify people with and without shoulder impairments. **Subjects.** Forty-six subjects ranging in age from 18 to 65 years ($\overline{X}$=30.0, SD=11.1) participated in this study. One group consisted of 20 subjects being treated for shoulder impairments, and one group consisted of 26 subjects without shoulder impairments. **Methods.** Two measurements in each test position were obtained bilaterally. From the bilateral measurements, we derived the difference measurement. Intraclass correlation coefficients (ICC [1,1]) and the standard error of measurement (SEM) were calculated for intrarater and interrater reliability of the difference in side-to-side measures of scapular distance. Sensitivity and specificity of the LSST for classifying subjects with and without shoulder impairments were also determined. **Results.** The ICCs for intrarater reliability were .75, .77, and .80 and .52, .66, and .62, respectively, for subjects without and with shoulder impairments in 0, 45, and 90 degrees of abduction. The ICCs for interrater reliability were .67, .43, and .74 and .79, .45, and .57, respectively, for subjects without and with shoulder impairments in 0, 45 and 90 degrees of abduction. The SEMs ranged from 0.57 to 0.86 cm for intrarater reliability and from 0.79 to 1.20 cm for interrater reliability. Using the criterion of greater than 1.0 cm difference, sensitivity and specificity were 35% and 48%, 41% and 54%, and 43% and 56%, respectively, for 0, 45, and 90 degrees of abduction. Sensitivity and specificity based on the criterion of greater than 1.5 cm difference were 28% and 53%, 50% and 58%, and 34% and 52%, respectively, for the 3 scapular positions. **Conclusion and Discussion.** Our results suggest that measurements of scapular positioning based on the difference in side-to-side scapular distance measures are not reliable. Furthermore, the results suggest that sensitivity and specificity of the LSST measurements are poor and that the LSST should not be used to identify people with and without shoulder dysfunction. [Odom CJ, Taylor AB, Hurd CE, Denegar CR. Measurement of scapular asymmetry and assessment of shoulder dysfunction using the Lateral Scapular Slide Test: a reliability and validity study. *Phys Ther*. 2001;81:799–809.]

Key Words: *Lateral Scapular Slide Test, Reliability, Shoulder dysfunction, Validity.*

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Some authors[1–4] have argued that alterations in scapular positioning can have an effect on shoulder function. Furthermore, scapular positioning is hypothesized to bear a direct relationship to scapular stability and the generation of muscular forces, because coordinated muscle patterns are believed to be requisite for normal glenohumeral joint function and muscle force production.[5–8] Thus, most authors of texts consider the assessment of scapular position to be one part of a comprehensive approach to evaluation of patients with suspected shoulder dysfunction.[9,10]

Several methods have been developed to characterize scapular position and to assess scapular stability.[4,11–15] Some of these methods are designed to measure scapular position, and they vary with regard to the position of the upper extremity during testing and the use of bony landmarks. For example, in a study of the relationship between scapular protraction and muscle force of the trapezius and pectoralis minor muscles, DiVeta et al[12] used a normalized ratio of scapular protraction. They defined *normalized scapular protraction* as the linear distance from the root of the scapular spine to the inferior angle of the acromion (ie, scapula width) relative to the distance between the inferior angle of the acromial process of the scapula and the spinous process of the T3 vertebra with the arm at rest in neutral (ie, scapular protraction). This ratio was used in an attempt to provide a size-corrected measure of scapular protraction. An increase in scapular protraction was indicated by a larger ratio.

Intrarater reliability for measurements of scapular protraction, as assessed on individuals without orthopedic or neurological impairments, has been reported by several investigators. DiVeta et al[12] reported ICCs of .94 for scapular width and .85 for scapular protraction, but much lower estimates, ranging from .34[16] to .78,[12] have been reported for the normalized ratio. Gibson et al[17] similarly reported high intrarater and interrater reliability estimates for scapular protraction (ie, distance between the inferior angle of the acromion and the third thoracic segment), but because of the low ICCs for the normalized ratio, they did not assess the reliability of measurements of scapula width or the normalized measure of scapular protraction. DiVeta et al[12] also found no association between scapular abduction and muscle performance of the middle trapezius and pectoralis minor muscles, leading these investigators to question the assumption of a linear relationship between muscle force production and posture.

Greenfield et al[11] replicated the study by DiVeta et al[12] and compared measurements of scapular position obtained through bony palpation with measurements obtained from radiographs. Using the method of palpation, Greenfield et al reported ICCs of .97 and .96, respectively, for intrarater and interrater reliability of the normalized ratio of scapular protraction and *r* values ranging from .73 to .79 in comparisons of scapular position variables between radiographic and palpation methods. The absence of differences in scapular protraction between people with and without overuse injuries of the shoulder led to conclusions similar to those reached

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All authors provided concept/research design. Dr Odom, Dr Taylor, and Dr Hurd provided writing, data analysis, and project management. Dr Odom and Dr Taylor provided consultation (including review of manuscript before submission). Dr Odom and Joel Bialosky provided data collection, and Mr Bialosky provided subjects and facilities/equipment.

This study was approved by the institutional review boards for the protection of human subjects at the University of Pittsburgh and Slippery Rock University.

Partial results of this study were presented at the 12th International Congress of the World Confederation for Physical Therapy, June 25–30, 1995, Washington, DC; the annual meeting of the National Athletic Trainers Association, June 14–17, 1995, Indianapolis, Ind; and the Combined Sections Meeting of the American Physical Therapy Association, February 8–12, 1995, Reno, Nev.

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by DiVeta et al regarding the questionable relationship between posture and dysfunction.

Differences in findings among the various studies may also be related to variation in training and clinical experience among examiners. Gibson et al,[17] for example, reported that they encountered difficulty palpating some of the bony landmarks, particularly the inferior angle of the scapula in Kibler's test positions of 45 and 90 degrees of abduction, despite a range of clinical experience among the examiners of between 6 and 11 years. Differences among examiners may account, in part, for their low ICCs for interrater reliability, although they reported high ICCs for intrarater reliability using Kibler's protocol. However, their use of a modified version of Kibler's protocol may also account for their low interrater reliability (Gibson et al[17] standardized the landmarks and measured the scapular distance from the inferior angle of the scapula to the spinous process of T8). Neither Greenfield et al[11] nor DiVeta et al[12] provided any direct information about the training or clinical experience of their examiners, although the examiner in the DiVeta et al[12] study was a graduate student at the time of data collection.

Kibler[4,18] proposed a method of characterizing scapular position in 3 different test positions that place the upper extremity in 0 degrees (test position 1), 40 degrees (test position 2), and 90 degrees (test position 3) of abduction in the coronal plane. Kibler's Lateral Scapular Slide Test (LSST) is used to assess scapular asymmetry by comparing right and left scapular distances, as measured from the inferior angle of the scapula to the corresponding thoracic spinous process in the horizontal plane. In addition to assessing scapular asymmetry, Kibler used the LSST to assess the ability of the scapular stabilizers to control the scapula under varying load positions. Test positions 2 and 3 place the shoulder in varying degrees of medial (internal) rotation and abduction, and were argued by Kibler[4] to require muscle activity of the upper and lower trapezius muscles and the serratus anterior muscle, thereby posing a challenge to the scapular stabilizers.

According to Kibler,[4] the LSST measures the ability of the posterior shoulder muscles to stabilize and position the scapula. Kibler originally contended that the scapular stabilizing musculature appeared to be symmetric and characterized by a bilateral difference of less than 1.0 cm in athletes without symptoms of shoulder pathology. He did not, however, provide evidence to support this contention. In athletes with symptoms of shoulder pathology, Kibler noted a difference of greater than 1.0 cm in side-to-side measurements of scapular distance associated with the presence of shoulder pathology or microtrauma, pain, and decreased shoulder function. Recently, Kibler[18] asserted that a bilateral difference of 1.5 cm should be the threshold for deciding whether scapular asymmetry is abnormal. Regardless of the threshold, Kibler contended that the injured side should exhibit a greater scapular distance than the uninjured side. Kibler[4] and Kibler and Chandler[19] noted differences when they measured symmetry with the shoulder placed in positions of either 45 or 90 degrees of abduction and medial rotation (ie, test positions 2 and 3, respectively). Inferences drawn by Kibler[18] and Kibler and Chandler[19] about scapular asymmetry and shoulder pathology, however, are based largely on unpublished work. Moreover, sensitivity and specificity for determining the presence of impairment have never been reported for either of the threshold criteria.

Although Kibler used the LSST to examine the relationship between scapular position and muscle performance in athletes who do overhead throwing, some clinicians and investigators[1–3,20] have hypothesized that a relationship exists among posture, muscle function, and movement. Furthermore, the argument proposed by Kibler for assessing scapular symmetry in athletes is a biomechanical one and rests on the premise that muscle deficiencies are associated with unstable scapulae. Kibler stated:

> If the scapula is abnormally mobile, the origin and insertion points of the muscles may be reversed so that the distal ends of the muscles are more stable and less force is developed. In addition, the more the scapula slides laterally, the shorter the muscle fibers will become, thereby altering the length-tension curve and making muscles less efficient in the eccentric or concentric work situation.[4(p528)]

Kibler[4] has suggested that the LSST may be used to monitor the scapular stabilizers in any rehabilitation program that involves strengthening exercises. Thus, a test designed to assess alterations in scapular positioning that may be associated with decreased muscular performance in athletes who engage in sports involving overhead throwing should serve equally well as a clinical tool for evaluating scapular symmetry and muscle performance in patients with shoulder injuries derived from other types of activities.

Gibson et al[17] are the only investigators to examine the reliability of measurements obtained with Kibler's protocol for measuring scapular position. They also compared Kibler's test with the method of DeVita et al.[12] Their results demonstrated that reliability varies among methods and in terms of intrarater versus interrater reliability. For example, both intrarater and interrater reliability of scapular distance measurements were high (Gibson et al[17] reported intrarater ICCs ranging from .92 to .95 and interrater ICCs ranging from .91 to .92) using the method of DiVeta et al.[12] However, although

Kibler's method achieved high intrarater reliability for measurements of scapular distance (ICCs ranged between .81 and .95 for the 3 test positions), interrater reliability was found to be poor for all 3 test positions (Gibson et al[17] reported ICCs ranging from .18 to .69). This finding has led some authors[21] to conclude that the LSST measurements may be too variable to be useful.

DiVeta et al[12] examined reliability on nonathletic subjects without shoulder dysfunction using a modified version of Kibler's protocol. Furthermore, DiVeta et al assessed the reliability of bilateral distance measurements, but they did not assess the reliability of the scapular difference measurements. We believe that this is a critical distinction between their study and ours. Clinical assessment of scapular asymmetry and shoulder dysfunction, based on Kibler's protocol, is determined not by the distance values, but by the difference in side-to-side measurements. The LSST is used in clinical practice and described in multiple texts,[9,10] yet the reliability of the measurements obtained with the LSST, which are derived measurements, remains questionable, and, importantly, the developer of the LSST has never reported its reliability. Moreover, the validity of measurements obtained with the LSST for predicting the presence of shoulder dysfunction has yet to be established. Further study of the LSST is clearly warranted.

The purpose of our study was twofold. First, we investigated the intrarater and interrater reliability of measurements obtained with the LSST. In contrast to Gibson et al,[17] we followed Kibler's protocol, and we examined and compared intrarater and interrater reliability in subjects with and without diagnosed shoulder pathology. Second, we wanted to extend the results of Gibson et al and examine the validity of the LSST for classifying subjects based on the presence or absence of diagnosed shoulder impairment.

Kibler's Lateral Scapular Slide Test

Kibler[4] measured the position of the scapula by deriving the difference in side-to-side measurements of scapular distance in 3 test positions. Position 1 involves placement of the shoulder in glenohumeral joint neutral. In position 2, the humerus is placed in a position of medial rotation, with 45 degrees of shoulder abduction in the coronal plane. In position 3, the upper extremity is placed in a position of maximal medial rotation, with 90 degrees of shoulder abduction in the coronal plane. Measurements of scapular position are taken bilaterally from the inferior angle of the scapula to the spinous process of the thoracic vertebra in the same horizontal plane (the reference vertebra) in all 3 test positions. A bilateral difference of greater than 1.0 cm in scapular distance measurements was the original criterion used by Kibler to determine a positive LSST, that is, abnormal scapular asymmetry associated with weakness of the stabilizing musculature.[4] More recently, that threshold has been shifted by Kibler to a bilateral difference of greater than 1.5 cm.[18]

Table 1.
Characteristics of Subjects With Shoulder Impairments[a]

Subject No.	Side of Dominance	Side Injured	Medical Diagnosis
3	R	R	Rotator cuff tendinitis
6	R	L	Tendinitis
13	R	L	Chronic subluxation
16	R	L	Dislocation
19	R	R	Rotator cuff tear
21	R	R	Labral tear
25	R	R	Dislocation
27	R	R	Subluxation
33	R	L	Instability
34	R	R	Impingement
36	R	L	Instability
37	R	R	Supraspinatus muscle tear
38	R	R	Rotator cuff tear
39	L	L	Impingement, instability
40	R	R	Impingement
41	R	R	Impingement
42	R	R	Instability
43	R	L	Rotator cuff strain
44	R	L	Long head of biceps muscle tear
45	R	L	Impingement

[a] All diagnoses were made by a physician prior to inclusion of subjects into the study. R=right, L=left.

Method

Subjects

A total of 46 subjects were recruited from the Center for Sports Medicine, University of Pittsburgh (Tab. 1). Subjects were men and women ranging in age from 18 to 65 years ($\overline{X}$=30.0, SD=11.1). Twenty subjects had unilateral or bilateral shoulder dysfunction (Tab. 1), and 26 subjects were being treated at the Center for Sports Medicine for medical diagnoses other than shoulder pathology. Medical diagnoses were made prior to inclusion of all subjects in the study, and for subjects with shoulder pathology these diagnoses included impingement syndrome or glenohumeral instability (n=8); rotator cuff tears, including long head of the biceps muscle (n=4); rotator cuff strain or tendinitis (n=3); glenohumeral dislocation or subluxation (n=4); and labral tears (n=1) (Tab. 1).

In addition, a self-reported history was obtained and visual screening performed on all subjects by the examining therapist prior to inclusion in the study. Subjects were excluded from participation, regardless of the medical diagnosis, if observation revealed postural or bony deformities, if the subjects had surgery within the previous year, or if they reported any history of systemic disease that would affect neuromusculoskeletal function. In order to participate in the study, subjects had to be able to actively assume and maintain a position of at least 90 degrees of shoulder abduction in the coronal plane and to fall between the ages of 18 and 65 years. The study was explained to the subjects, and subjects signed an informed consent statement prior to participation in the study.

Subjects who met the inclusion criteria were assigned to a group of subjects with shoulder dysfunction (n=20), based on the presence of shoulder pathology as diagnosed by a physician, or to a group of subjects without shoulder dysfunction (n=26), based on a medical diagnosis of something other than shoulder pathology. A sample of convenience was used whereby subjects who met the inclusion criteria were assigned to examiners based on therapist availability. Nineteen subjects with shoulder pathology were right-side dominant (Tab. 1). Eleven subjects had injuries of the right shoulder, and 9 subjects had injuries of the left shoulder.

Examiners
Six physical therapists at the Center for Sports Medicine, University of Pittsburgh, administered the LSST to the subjects. Participating therapists were required to have a minimum of 1 year of practice in outpatient orthopedics ($\overline{X}$=5.8, SD=1.16, range=4–7). We considered this criterion to reflect the experience level of an average clinician working in an outpatient orthopedic setting.

Instrumentation
In an attempt to reduce rater bias, we used unmarked sections of string rather than a flexible tape measure to measure scapular distance.[12,17] A new string was used for each measurement. The sections of string, approximately 45 cm (18 in) in length, were cut prior to testing and coded for subject, trial, side, and examiner. During testing, the examiner marked one end of the string with a dot using a roller-ball pen and then placed the marked portion of the string on the spinous process of the reference vertebra. While maintaining this position of the string, the examiner pulled the other end of the string taught to the inferior angle of the scapula. The string then was marked with a dot at this bony landmark with the same pen. On a separate occasion, one of us (CJO) secured a tape measure to a flat surface and measured each section of string for the linear scapular distance to the nearest 0.1 cm.

Procedure
Prior to initiation of data collection, the lead author (CJO) contacted the Director of Outpatient Physical Therapy and Sports Medicine at the Center for Sports Medicine, University of Pittsburgh. The director identified a physical therapist who served as the lead therapist for the study. The lead therapist was provided with a written study protocol that included information on the purpose of the study, informed consent, inclusion and exclusion criteria, and measurement procedure. The lead therapist received instruction in the application of the LSST by one of us (CJO).* In a single session, the lead therapist was trained in the measurement procedure, which included appropriate patient positioning for the 3 test positions, palpation of the inferior angle of the scapula and spinous process of the reference vertebra (Fig. 1), and placement and marking of the string used to record distances.

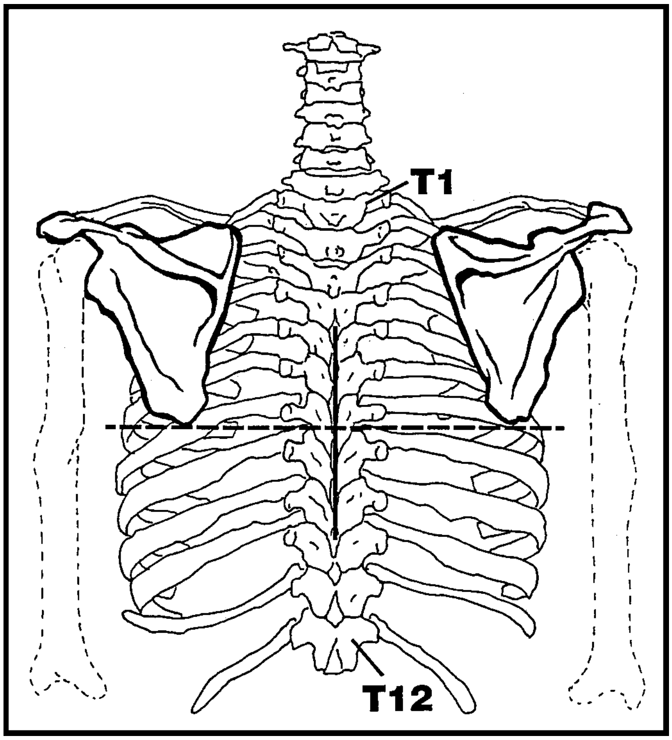

Figure 1.
Bony landmarks for the Lateral Scapular Slide Test.

The lead therapist practiced the procedure until he was sufficiently competent to train the other 5 therapists, as determined by the lead author. The lead therapist then instructed the remaining 5 therapists in the LSST measurement protocol and technique and directed data collection for the study. Data collection on the subjects was initiated when all 6 therapists expressed their readiness to proceed. The presence or absence of shoulder pathology was not known to the physical therapists during testing. In addition, the administering physical

* The lead author spent 2½ years as an athletic trainer at the Lexington Clinic Sports Medicine Center, Kentucky, where Dr Ben Kibler was the Medical Director. During that time, the lead author was educated in the application of the LSST by Dr Kibler and used the test in the routine screening of interscholastic and intercollegiate athletes.

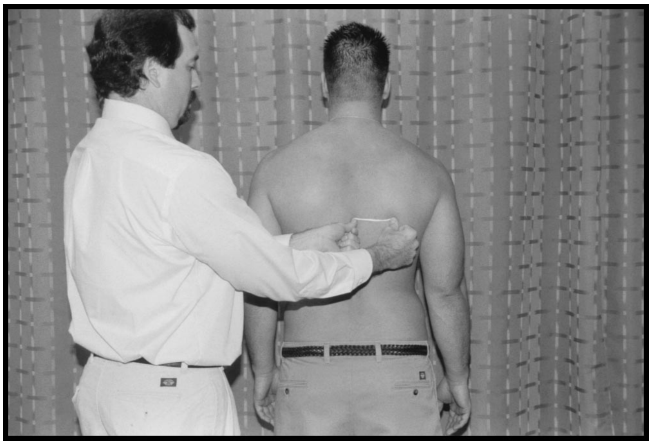

Figure 2.
Test position 1.

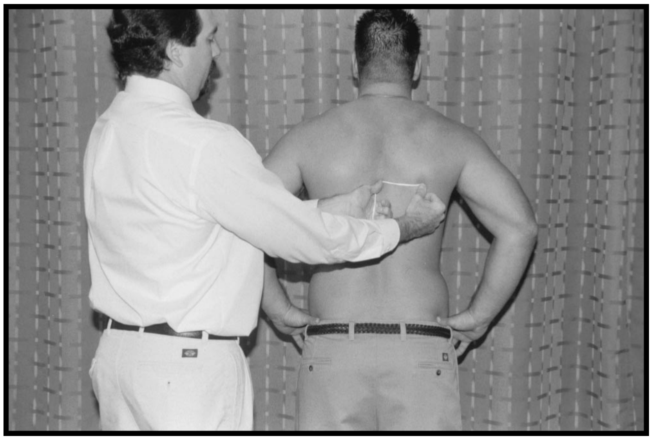

Figure 3.
Test position 2.

therapists were unaware of both their measurements and those of the other raters.

Prior to testing, subjects disrobed so that the spine and both scapulae were in full view of the physical therapist. Two therapists measured each subject during a test session, but the combination of therapists varied across subjects. Random pairing of therapists for each subject was not possible because of the clinical procedures.

To aid in maintaining a consistent posture during the test session, subjects were instructed to fix their eyes on an object in the examination area. The procedure for data collection followed the precise protocol as described by Kibler.[4] Each subject was instructed to actively achieve the first test position (both arms at the sides in glenohumeral joint neutral; Fig. 2). When the test position was obtained and confirmed by the examiner, the inferior-most aspect of the inferior angle of the scapula and the adjacent spinous process of the reference vertebra in the same horizontal plane were identified through palpation. A string was marked at one end and placed on the spinous process of the reference vertebra. Then, while maintaining the position of the string on the reference vertebra, the examiner pulled the string taut to the inferior angle of the scapula and marked the string at this landmark. The examiner obtained measurements bilaterally.

The subject was then instructed to reposition the upper extremities from the test position to neutral and then back to the desired test position, and the procedure was replicated by the same examiner to assess intrarater reliability. This procedure was repeated again for test positions 2 (subject actively placed both hands on the ipsilateral hips and placed the humerus in medial rotation at 45° of abduction in the coronal plane; Fig. 3) and 3 (subject actively extended both elbows and placed the upper extremities in a position of maximum medial

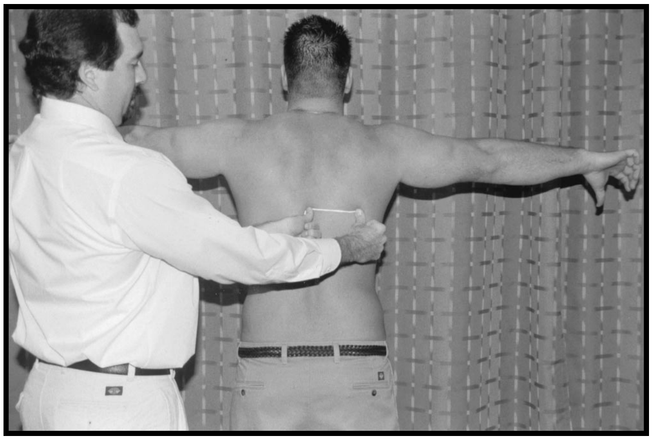

Figure 4.
Test position 3.

rotation at 90° of abduction in the coronal plane; Fig. 4). After one examiner obtained a complete set of measurements on a subject in all 3 test positions, the entire testing protocol was repeated by the second examiner to evaluate interrater reliability.

Data Analysis

In this investigation, we examined the value of the difference in side-to-side measurements of scapular distance. For the subjects with shoulder impairment, the measurement was derived by subtracting the value for the uninjured side from the value for the injured side and then obtaining the difference for each test position. For the subjects without shoulder impairment, the value of the difference was obtained by subtracting the value for the left side from the value for the right side. Descriptive statistics were calculated on the values of the difference measurements. Paired *t* tests also were carried out to test for differences in scapular distance measurements between the injured and uninjured sides of the subjects with shoulder dysfunction.

Table 2.
Means, Standard Deviations, and Ranges for Subjects With and Without Shoulder Impairments for Scapular Difference Measurements for the Three Test Positions[a]

Measure	Subjects Without Shoulder Impairments			Subjects With Shoulder Impairments		
	$\overline{X}$	SD	Range	$\overline{X}$	SD	Range
Test position 1	0.64	1.36	−2.60–5.30	0.17	1.35	−2.70–5.00
Test position 2	0.15	1.35	−4.30–2.70	−0.04	1.21	−2.90–2.50
Test position 3	0.06	1.96	−6.50–3.80	−0.24	1.58	−4.60–3.50

[a] Differences for subjects without shoulder impairments derived by subtracting the left side from the right side. Differences for subjects with shoulder impairments derived by subtracting the uninjured side from the injured side. All measurements are expressed in centimeters. Test position 1=0° of abduction, test position 2=45° of abduction, test position 3=90° of abduction.

Intrarater and interrater reliability for both groups of subjects in each of the 3 test positions was determined using ICC (1,1).[22,23] This ICC model is based on a one-way analysis of variance (ANOVA) design and is the model of choice because, although 6 examiners were recruited, only 2 examiners evaluated a given subject and scores were pooled from all 6 raters.[22,23] Intrarater reliability was calculated by comparing the values for scapular differences obtained from 2 trials by each examiner (n=46). Interrater reliability was calculated by comparing the values for scapular differences obtained in the first trial by each examiner (n=43). Systematic error between 2 raters during the first 3 test sessions (one rater was observed to deviate from the prescribed protocol but obtained consistent measurements for each test position) resulted in the elimination of the first 3 subjects from analysis of interrater reliability. The standard error of measurement (SEM=SD [$\sqrt{1-\text{ICC}}$]) was calculated for each measurement of scapular difference.[24]

We applied a criterion-referenced test of validity[25] to assess the ability of the LSST to correctly classify subjects according to their *a priori* physician's diagnosis of the presence or absence of shoulder injury. Sensitivity and specificity of the LSST have been reported for the 3 test positions.[26,27] A sensitive test correctly identifies those individuals with a given condition, whereas a specific test correctly identifies those individuals without a given condition. The thresholds of scapular differences of greater than 1.0 cm and greater than 1.5 cm were both tested.[4,18] All statistics were computed using SPSS[X†] version 10,[28] and statistical tests were considered significant at $P<.05$.

Reliability of the Scapular Distance Measurements

Prior to calculating the ICCs for the side-to-side difference measures, we calculated ICCs for the scapular distance measures in order to assess the reliability of the measurement technique. The ICCs (1,1) for intrarater reliability of scapular distance measurements ranged from .91 to .97 (SEM=0.31–0.63 cm) for the subjects without shoulder dysfunction and from .81 to .93 (SEM=0.52–0.79 cm) for the subjects with shoulder dysfunction. The ICCs (1,1) for interrater reliability ranged from .70 to .95 (SEM=0.31–1.15 cm) for the subjects without shoulder dysfunction and from .71 to .91 (SEM=0.45–1.02 cm) for the subjects with shoulder dysfunction.

Results

Means, standard deviations, and ranges for scapular difference measurements in both groups of subjects are presented in Table 2. There were no differences in scapular distance measurements between the involved and uninvolved sides in the subjects with shoulder dysfunction (Tab. 3). The largest average difference between involved and uninvolved sides was less than 0.5 cm (Tab. 3), which is less than the SEMs for the scapular distance or side-to-side difference measures.

Intrarater ICCs for the measurements of scapular difference ranged from .75 to .80 (SEM=0.58–0.80 cm) for the subjects without shoulder dysfunction and from .52 to .66 (SEM=0.57–0.86 cm) for the subjects with shoulder dysfunction (Tab. 4). Interrater ICCs ranged from .43 to .74 (SEM=0.79–1.20 cm) for the subjects without shoulder dysfunction and from .45 to .79 (SEM=0.79–1.10) for the subjects with shoulder dysfunction (Tab. 5).

Using the threshold of a bilateral difference of greater than 1.0 cm, sensitivity and specificity of the LSST were 35% and 48% for test position 1, 41% and 54% for test position 2, and 43% and 56% for test position 3. Modifying the threshold ±0.5 cm did not substantially alter these results. Sensitivity and specificity using the criterion of greater than 1.5 cm were 28% and 53% for test position 1, 50% and 58% for test position 2, and 34% and 52% for test position 3. Analysis of a subgroup comprising the largest cohort of subjects with a single diagnosis (impingement syndrome/instability, n=8)[29] improved the specificity of the LSST using both criteria. The specificity ranged between 69% and 79% based on the criterion of greater than 1.0 cm and between 69%

† SPSS Inc, 444 N Michigan Ave, Chicago, IL 60611.

Table 3.
Means, Mean Differences, Standard Deviations, and Results of Tests of Statistical Significance for Differences in Measurements of Scapular Distance Between Injured and Uninjured Sides in the Subjects With Shoulder Impairments[a]

Side/Test Position	$\bar{X}$	Difference	SD	Sample Size	*P*	Significance[b]
Right side injured						
Position 1						
Right	10.09	0.40	1.3	11	.16	NS
Left	9.70					
Position 2						
Right	9.80	0.05	1.3		.88	NS
Left	9.85					
Position 3						
Right	10.52	0.39	1.3		.19	NS
Left	10.91					
Left side injured						
Position 1						
Right	9.62	0.33	1.9	9	.46	NS
Left	9.95					
Position 2						
Right	9.38	0.17	1.1		.53	NS
Left	9.22					
Position 3						
Right	11.42	0.09	2.0		.84	NS
Left	11.33					

[a] Results derived from paired sample *t* tests (df=21). Means, mean differences, and standard deviations expressed in centimeters. Test position 1=0° of abduction, test position 2=45° of abduction, test position 3=90° of abduction.
[b] NS=nonsignificant at $P<.05$.

Table 4.
Intrarater Reliability (ICC [1,1]) for Measurements of Scapular Difference for Subjects With and Without Shoulder Impairments[a]

Test Position	Subjects Without Shoulder Impairments			Subjects With Shoulder Impairments		
	ICC	SEM	95% CI	ICC	SEM	95% CI
Position 1	.75	0.61	0.56–0.85	.52	0.78	0.10–0.74
Position 2	.77	0.58	0.60–0.86	.66	0.57	0.36–0.82
Position 3	.80	0.80	0.65–0.88	.62	0.86	0.27–0.79

[a] The standard error of measurement (SEM) (in centimeters) is calculated from the standard deviation derived from the average of the 2 trials of each examiner. ICC=intraclass correlation coefficient, CI=confidence interval. Test position 1=0° of abduction, test position 2=45° of abduction, test position 3=90° of abduction.

and 76% based on the criterion of greater than 1.5 cm. However, sensitivity substantially decreased, ranging between 18% and 24% for a bilateral difference of greater than 1.0 cm and between 0.9% and 33% for a bilateral difference of greater than 1.5 cm.

Discussion

Intrarater reliability of the difference in side-to-side scapular distance measurements was low in all 3 test positions. Reliability values were higher for the subjects without shoulder dysfunction than for the subjects with shoulder dysfunction in all test positions. Interrater reliability was also low, particularly for test positions 2 and 3 in the subjects with shoulder dysfunction. Although our results did not demonstrate a consistent pattern of decrease in reliability from test position 1 to test position 3, as was noted by Gibson et al,[17] differences in our findings are likely explained by the fact that we followed Kibler's protocol and examined reliability for the difference values rather than for the scapular distance measurements. The SEMs for interrater reliability were higher than those for intrarater reliability in all cases, and SEMs for interrater reliability increased consistently from the test position 1 to test position 3. In some cases, SEMs exceeded the mean value of the difference. Because all examiners received considerable training and much of it was based on the knowledge of a person who studied with the test developer, reliability in our study might be higher than that obtained by other examiners.

The SEM reflects the error with which scapular position can be measured, with smaller errors reflecting more reliable measurements. Based on the SEMs, there was a

Table 5.
Interrater Reliability (ICC [1,1]) for Measurements of Scapular Difference for Subjects With and Without Shoulder Impairments[a]

Test Position	Subjects Without Shoulder Impairments			Subjects With Shoulder Impairments		
	ICC	SEM	95% CI	ICC	SEM	95% CI
Position 1	.67	0.79	0.25–0.85	.79	0.79	0.46–0.91
Position 2	.43	1.08	−0.29–0.75	.45	0.79	−0.38–0.78
Position 3	.74	1.20	0.41–0.88	.57	1.10	−0.23–0.85

[a] The standard error of measurement (SEM) (in centimeters) is calculated from the standard deviation derived from the first trial of each examiner. ICC=intraclass correlation coefficient, CI=confidence interval. Test position 1=0° of abduction, test position 2=45° of abduction, test position 3=90° of abduction.

95% probability that the true value of the difference was within ±1.96 SEMs of the obtained measurement. For example, the mean value of the derived difference in the subjects with shoulder dysfunction for test position 1 was 0.64 cm. A SEM of 0.79 cm (Tab. 5) means that the true value of the difference could have been as low as −0.94 cm or as large as 2.22 cm. Although the ICCs and SEMs varied by group and test position, the results demonstrated that the value of the difference in side-to-side scapular distance measurements, as prescribed by the LSST, was not reliable for assessing the presence and magnitude of scapular asymmetry.

Results of previous reliability studies of scapular positioning, as well as those reported in this article, demonstrate that measurements of linear distance related to the scapula can be reliable.[11,12] In our study, the examiners were able to locate, palpate, and measure the inferior angle of the scapula and the adjacent spinous process. However, for purposes of clinical decision-making, the critical value of the LSST is the value of the difference, which we found to be unreliable. Difference measurements have been found to be equally unreliable in studies of innominate asymmetry.[30–32]

Correlations are influenced by the variance in measurements. Because the value of the difference exhibits less variance than the distance measurements, lower correlations would be expected, and we obtained lower ICCs on the values of the differences than on the distance measurements. Although ICCs for scapular distance measurements were higher than those obtained for the difference measurements, SEMs for the distance measurements were high as well and frequently exceeded the purported threshold for identification of scapular asymmetry associated with shoulder dysfunction. The magnitude of the error broadened the range within which the actual values of the side-to-side distance measurements could be expected to fall, with the result that subjects had a 95% probability of exhibiting a scapular difference measurement considerably greater or less than either the >1.0-cm or >1.5-cm threshold, regardless of whether they were diagnosed with or without shoulder dysfunction. Thus, the net effect of assessing reliability on the distance measurements versus the value of the difference measurements is essentially the same—both measurements are unreliable for determining a degree of scapular asymmetry that could be used to predict weakness of the scapular stabilizers and associated shoulder dysfunction.

The measurement procedure used in our study is relatively simple. However, we attempted to provide standardized training and practice of the measurement technique to all examiners, a protocol that may not be generalizable to all examiners. Thus, our results might be more reliable than would otherwise be expected. Furthermore, the ICCs for the scapular distance measurements indicated high agreement among examiners. Nevertheless, differences in measurement technique and clinical experience among examiners may at least partially account for our findings. Because the examiners were unaware of either their own measurements or those of the other examiners, reliability estimates are not likely to have been influenced by rater bias. Although we did not control for side of dominance, Gibson et al[17] reported no differences in scapular position of the dominant and nondominant extremities based on the side-to-side distance measurements obtained with the LSST.

As noted earlier, Kibler[4] assumed that the injured side should exhibit a longer scapular distance than the uninjured side. Of the 20 subjects with shoulder dysfunction, 16 were diagnosed with impingement syndrome, shoulder instability (or the instability-impingement complex),[33] shoulder subluxation or dislocation, or labral tears, all of which can be associated with increased mobility of the shoulder.[34] Nevertheless, in our study, the opposite pattern was frequently observed, with the injured side exhibiting a shorter scapular distance than the uninjured side (Tab. 3), although these differences were not statistically significant.

Means for the absolute values of scapular difference measurements were larger in the subjects without shoulder dysfunction than in the subjects with shoulder dysfunction and exceeded the threshold of greater than

1.0 cm (Tab. 2). Furthermore, and in contrast to Kibler's findings, our results revealed no differences in side-to-side distances in the subjects with shoulder dysfunction (Tab. 3). Inasmuch as hypomobility of the shoulder is thought to result in scapular asymmetry and shoulder dysfunction,[35] one problem with the LSST may be the *a priori* assumption of a unidirectional change in scapular positioning associated with shoulder injuries.

Sensitivity and specificity of the LSST measurements were poor for all 3 test positions, regardless of the threshold. The sensitivity of a measurement reflects the extent to which those subjects who have shoulder dysfunction also have a positive test, whereas specificity is a measure of the extent to which those subjects without shoulder dysfunction have a negative test.[26,27] Our results demonstrated that the LSST fared little better than random chance at identifying people with and without shoulder dysfunction. Improved specificity of the measurements for subjects with a single diagnosis simply demonstrates the improved ability of the LSST to be used to correctly identify those subjects without the condition. The failure of the LSST to be useful in identifying subjects with and without diagnosed shoulder impairment is consistent with findings of previous investigators who failed to find a relationship among scapular positioning, muscle performance, and shoulder dysfunction.[11,12]

One possible explanation for the poor sensitivity and specificity of the LSST is that we applied the LSST to a heterogenous sample of patients with multiple types of shoulder injuries. Kibler[4] has primarily applied the LSST to determine scapular asymmetry in athletes who do overhead throwing. Many of the types of injuries Kibler associated with these athletes, including shoulder instability and rotator cuff impingement, subluxation or dislocation, and glenoid labral tears, can result from other athletic activities, as well as from nonathletic overuse and single traumatic events. A number of the injured subjects who participated in our study were being treated for these sorts of injuries. However, athletic and nonathletic populations may differ in the extent to which they have asymmetry associated with shoulder dysfunction.

Clinical Implications

Our results indicate that measurements obtained with the LSST, because of poor reliability, should not be used to characterize the presence or absence of scapular asymmetry. Furthermore, because measurements obtained with the LSST failed to be useful for identifying subjects with and without shoulder impairment based on the degree of scapular asymmetry, we question the use of the LSST for assessing scapular asymmetry in patients with suspected shoulder dysfunction. In light of evidence that individuals without shoulder impairments exhibit some degree of abnormal posture and postural changes associated with age,[20,36] the application of a threshold for determining abnormal scapular asymmetry in the absence of anthropometric standards for normal variation in scapular asymmetry is problematic. Despite some data on angular values for scapular orientation,[15] there are no comparable data for the measurements of scapular position defined by the LSST.

Numerous investigators[13,15,25,37,38] have criticized the use of simple 2-dimensional methods for determining meaningful alterations in scapular positioning. Although such methods can be used to measure the simple linear displacement of the scapula on the thorax, they fail to assess scapular motions that involve twisting and rotation,[8] such as tipping or tilting of the scapula about an axis parallel to the scapular spine and winging about a vertical axis. For example, a 3-dimensional study of scapular orientation has shown that, during normal humeral elevation in the scapular plane, the scapula exhibits a progressive pattern of upward rotation and posterior tipping and a decrease in medial rotation.[15] These changes in scapular positioning are accompanied by alterations in activity of the rotators and stabilizers of the scapula, suggesting that tipping and winging of the scapula are important components of normal shoulder kinematics.[15] Ludewig and Cook[37] further demonstrated that, compared with subjects without shoulder impairments, patients with symptoms of shoulder impingement exhibited a decrease in upward rotation of the scapula and increases in both anterior tipping and medial rotation coincident with alterations in muscular activity.

These data provide compelling evidence that simple 2-dimensional methods for assessing scapular positioning are limited. However, 3-dimensional methods can be both time-intensive and costly, and they have not yet become routinely used in the clinic or been shown to be useful in clinical practice. Moreover, the relationship between simple linear measures and more complex 3-dimensional measures has not yet been established. Thus, although 3-dimensional methods appear to hold greater promise for enhancing our understanding of the relationships among scapular orientation, muscle performance, and shoulder dysfunction, much work remains to be done to render these methods clinically accessible.

Conclusion

The results of our investigation demonstrate that measurements obtained with the LSST cannot be used to reliably assess the presence or magnitude of scapular asymmetry. The LSST does not appear to be useful for identifying the injured side based on the value of the derived difference in scapular distance measurements.

Sensitivity and specificity of the LSST are unacceptably low, with the LSST performing little better at classification than chance alone. These results are consistent with previous findings that have demonstrated low reliability of derived difference measurements of asymmetry and weak associations between measurements of scapular position and muscle performance. Our findings strongly suggest that the use of the LSST for evaluating and treating shoulder dysfunction should be re-evaluated.

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