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Clinical Assessment of Scapular Positioning in Musicians: An Intertester Reliability Study

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Context: The reliability of the measurement of the distance between the posterior border of the acromion and the wall and the reliability of the modified lateral scapular slide test have not been studied. Overall, the reliability of the clinical tools used to assess scapular positioning has not been studied in musicians.

Objective: To examine the intertester reliability of scapular observation and 2 clinical tests for the assessment of scapular positioning in musicians.

Design: Intertester reliability study.

Setting: University research laboratory.

Patients or Other Participants: Thirty healthy student musicians at a single university.

Main Outcome Measure(s): Two assessors performed a standardized observation protocol, the measurement of the distance between the posterior border of the acromion and the wall, and the modified lateral scapular slide test. Each assessor was blinded to the other's findings.

Results: The intertester reliability coefficients (κ) for the observation in relaxed position, during unloaded movement, and during loaded movement were 0.41, 0.63, and 0.36, respectively. The κ values for the observation of tilting and winging at rest were 0.48 and 0.42, respectively; during unloaded movement, the κ values were 0.52 and 0.78, respectively; and with a 1-kg load, the κ values were 0.24 and 0.50, respectively. The intraclass correlation coefficient (ICC) of the measurement of the acromial distance was 0.72 in relaxed position and 0.75 with the participant actively retracting both shoulders. The ICCs for the modified lateral scapular slide test varied between 0.63 and 0.58.

Conclusions: Our results demonstrated that the modified lateral scapular slide test was not a reliable tool to assess scapular positioning in these participants. Our data indicated that scapular observation in the relaxed position and during unloaded abduction in the frontal plane was a reliable assessment tool. The reliability of the measurement of the distance between the posterior border of the acromion and the wall in healthy musicians was moderate.

Key Words: scapular winging, observation, shoulder

Key Points

- Visual observation of the scapula was a reliable tool for screening scapular winging and scapular tilting during unloaded movement in healthy musicians.
- Interobserver reliability was better during unloaded movement than at rest, emphasizing the usefulness of dynamic evaluation in screening healthy musicians.
- Measuring scapular protraction using the acromial distance between the posterior border of the acromion and the wall at rest and during active retraction yielded moderate interobserver reliability.
- The modified lateral scapular slide test was not a reliable tool for assessing scapular position in healthy musicians.

Because the muscular system is the major contributor to passive positioning and active functional stability of the scapula,[1,2] injuries can result from overuse in sports and performing arts, such as music.[3] Performance-related musculoskeletal problems are frequent among instrumental performing artists and other occupational groups that carry out repetitive movements with prolonged static and dynamic loading of the upper extremity muscles.[3,4] In fact, Ackermann et al[5] reported that from 50% to 88% of professional musicians have upper limb performance-related injuries or pain, and they suggested that these injuries are linked with abnormal scapular positioning patterns. The position of the scapula in relation to the humerus is essential for efficient upper limb movement.[6–8] In addition, researchers[2,5,8–19] have shown that scapular positioning is abnormal in individuals with shoulder impingement syndrome, shoulder instability, neck pain, cervicogenic headaches, or postoperative shoulder disorders.

To assess this abnormal scapular positioning, most researchers apply expensive and specialized equipment for assessing scapular positioning. These methods are accurate, with measurement errors between 1.1° and 3.7°, but they are not easy to use in clinical practice.[20] For these reasons, the use of these measurement tools in the clinic is limited, so assessment strategies for scapular positioning that are inexpensive and easy to apply are needed. These tools could help the clinician to identify movement faults of the scapula during observation and even during movement retraining and to develop preventive exercise programs for healthy musicians. Clinical assessment strategies for scapular positioning

Table 1. Clinical Test Protocol Overview

Clinical Test	Test Positions	Within-Test Positions
Visual observation	Resting posture	Resting with both arms relaxed
		Hands placed on ipsilateral hips
		Arms in 90° of humeral abduction
	Active unloaded abduction to 180°	
	Active loaded abduction to 180°	With 1-kg load
Acromial distance	Shoulders relaxed	
	Shoulders bilaterally retracted	
Modified lateral scapular slide test	90° of humeral abduction	With 1-kg load
	180° of humeral unloaded abduction	

are available but require further study of the clinimetric properties.[21,22]

Many clinicians use the observation of the scapula to assess the scapular resting position. Observation of scapular positioning during humeral movement enables clinicians to assess the kinematic rhythm between glenohumeral abduction and scapular upward rotation. Kibler et al[23] described a qualitative evaluation of scapular dysfunction. They created a scapular dyskinesis system with 4 types to categorize abnormal scapular motion, and they concluded that this qualitative evaluation method may allow clinicians to standardize the categorization of dynamic scapular dysfunction patterns. However, refinement of this system,[23] such as through inclusion of both dynamic and in vivo evaluations, is needed.

Clinicians can also use the acromial distance to measure forward shoulder posture. Researchers[16,24] have suggested that forward shoulder posture contributes to head, shoulder, and neck pain. Authors[1,9] have noted that forward shoulder protraction is indicative of pectoralis minor muscle length and can be measured using the distance between the posterior border of the acromion and the examining table at rest and during active retraction. Individuals with short pectoralis minor muscles have demonstrated scapular kinematics similar to individuals with shoulder impingement syndrome, supporting the inclusion of the assessment of pectoralis minor muscle length for analyzing scapular positioning.[12,13,25,26] Using human cadavers, Borstad and Ludewig[25] validated the measurement of the pectoralis minor muscle length. They found that shortening of the pectoralis minor muscle could result in a lack of posterior tilting and, therefore, could reduce subacromial space.[25] From a clinical perspective, the supine position may reduce scapular protraction and change the muscular activity needed for scapular stability. However, measuring the distance between the posterior border of the acromion and the examining table by placing the patient in the upright position may diminish the influence of gravity on scapular protraction and, therefore, may provide a more clinical and realistic view of scapular positioning.

Researchers[24] have examined the intraobserver reliability and validity of the distance between the acromion and a wall. Because of its clinical relevance, the interobserver reliability of the measurement between the posterior border of the acromion and a wall as a measure of scapular protraction should also be examined.

Finally, scapular positioning can be measured with the lateral scapular slide test (LSST). Kibler[27] originally designed the LSST to assess scapular asymmetry under varying loads. However, researchers[13,28] have found that asymmetry is not indicative of shoulder dysfunction and that scapular positioning is commonly asymmetric in asymptomatic participants. Other investigators[29] have found that the LSST is unreliable for measuring the difference in side-to-side distance. The results of studies[1,21,28,29] examining the reliability of the LSST are still inconclusive.

Only McKenna et al[20] and Su et al[30] have studied the reliability of clinical measurements of scapular positioning in a population requiring musculoskeletal performance, but they did not include musicians. In addition, studies[1,21,22,28,29,31] of the validity, reliability, and clinical relevance of several clinical measurements of scapular positioning have been inconclusive. Thus, the purposes of our study were to determine the reliability of scapular observation during clinical assessment and to determine the reliability of the modified version of the LSST and the measurement of the acromion-to-wall distance in unimpaired active musicians.

METHODS

Research Design

Because the clinical use of the standard LSST remains questionable, we implemented only a modified version of the LSST. In addition, the reliability of this modified LSST had not been studied and, therefore, was examined. Before the study, the 2 assessors (K.D.C. and M.G., both of whom hold bachelor's degrees in physiotherapy) underwent a 4-hour training session conducted by 2 physiotherapists (F.S. and J.N.), one of whom holds a master's degree in manual therapy and has 10 years of clinical experience and one of whom holds a master's degree in sports physiotherapy and has 5 years of clinical experience. During the training session, the assessors were taught how to perform an accurate measurement of scapular positioning and participated in pilot testing with healthy volunteers. Each assessor and instructor performed an evaluation without knowledge of the others' outcomes. When all assessors and instructors finished their evaluations, their results were compared and discussed. Both assessors attained the same outcomes as their instructors.

After measuring the participants' mass and height, we performed the clinical tests in the following order: observation protocol, measurement of the distance between the posterior border of the acromion and the wall (with the shoulder girdle at rest and with active shoulder retraction), and the modified LSST (Table 1). Because high-heeled shoes could have influenced posture and consequently scapular positioning, we instructed participants to stand

Figure 1. Observation of the scapula in resting position with both arms relaxed shows winging of the right scapula.

barefoot. Both assessors independently evaluated both shoulders. First, assessor 1 evaluated both shoulders and exited the room. Second, assessor 2 entered the room and performed the same measurements. Each assessor was blinded to the other's outcomes but was not blinded to the side-to-side differences. Palpation was used to find the bony landmarks. Lewis et al[32] reported that palpation is a valid method to identify the position of the scapula. To reduce the altering effect of natural light on the body, only overhead artificial lighting was used.

Participants

We recruited a sample of convenience comprising 30 music students from a single university (17 men [56.7%], 13 women [43.3%]; age = 21.5 ± 5.8 years, height = 174.7 ± 8.0 cm, body mass index = 20.2 ± 1.9 kg/m^2; 24 right-hand dominant, 6 left-hand dominant). All variables were normally distributed (Kolmogorov-Smirnov test, $P > .05$; data not shown). To be included in the trial, participants had to play a musical instrument at least 10 hours per week. Exclusion criteria included any shoulder pain or disorder within 1 year before the study and any history of shoulder surgery. All participants received an information leaflet and provided written informed consent. The study protocol was approved by the Medical Ethics Committee of the University of Antwerp (reference No. 4/38/109).

Visual Observation

The observation was performed with the participants standing and relaxed. The scapula was observed in resting posture, during active unloaded movement, and during active loaded movement. Electromyographic evaluation has shown altered scapular kinematics after a shoulder elevation fatigue protocol.[33] Ebaugh et al[33] found that healthy participants demonstrated more upward and external rotation of the scapula during arm elevation after the fatigue protocol. As muscle fatigue is an influencing factor during loaded movement,[10,33,34] we used a weight to determine if this influenced scapular assessment reliability. We observed the participant from dorsal (frontal-plane) and lateral (sagittal-plane) positions. During scapular observation at rest, we observed all participants bilaterally in 3 positions: resting with both arms relaxed (thumbs facing forward), hands placed on ipsilateral hips (thumbs facing backward), and arms in 90° of humeral abduction in the frontal plane (thumbs facing up) (Figures 1 through 3).

To assess faulty scapular resting position, we needed a precise definition of *ideal scapular resting position*. We defined *ideal scapular resting position* in the following way: the superior angle of the scapula and the lateral border of the acromion are located approximately on the same level as T2 and, thus, without excessive elevation or depression[35] and 30° internally rotated with respect to the frontal plane.[36] The orientation of the glenoid fossa should point downward[37] (10° below the horizontal plane), but some investigators[38] have concluded the opposite. In addition, the entire medial border of the scapula should be parallel to the thoracic midline[39]; the scapula of the dominant side should be lower and farther away from the spine compared with the nondominant side[39]; the medial border and inferior angle should be flat against the chest wall; the superior angle should be level with the spinous processes of

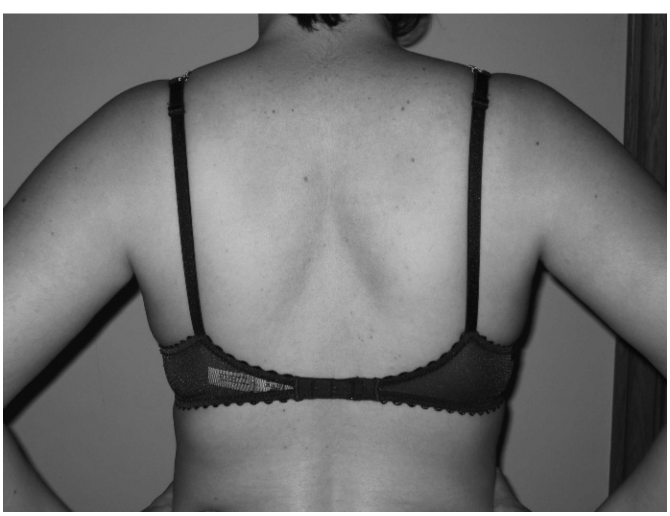

Figure 2. Observation of the scapula with hands on ipsilateral hips.

Figure 3. Observation of the scapula with arms abducted to 90° in the frontal plane.

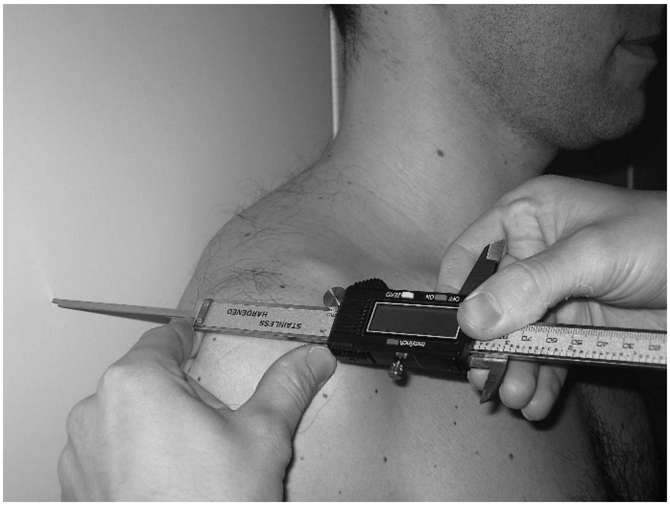

Figure 4. Measurement of the distance between the acromion and the wall.

Figure 5. Modified lateral scapular slide test: arms abducted to 90° in the frontal plane with a 1-kg load.

T3 or T4; and the inferior angle should be level with T7, T8, T9, or even T10.[6] A forward-tilting and downward-rotated scapula can be observed by forward and downward dropping of the acromion.[6] Scapular positioning was deemed impaired when deviations from the ideal resting position occurred: (1) the inferior angle of the scapula became prominent dorsally, rotating about the horizontal axis (tilting); (2) the entire medial border of the scapula became prominent dorsally, rotating about the vertical axis (winging); (3) the medial border of the scapula showed excessive translation around the chest wall (protraction); (4) the scapula showed excessive elevation or depression (elevation or depression); or (5) the medial border of the scapula was positioned parallel to the spine only at rest with both arms relaxed (rotation) (Figure 1). If one of these criteria was satisfied, we judged scapular positioning to be impaired.

Next, the participant performed active unloaded movement in standing posture. We instructed the participant to perform bilateral shoulder abduction (0°–180°) in the frontal plane. The same criteria were used after adding one aspect: early rotation of the scapula during the first 60° of glenohumeral abduction in the frontal plane. Finally, during scapular observation with active loaded movement, we instructed the participant to hold a 1-kg load in each hand and slowly perform bilateral shoulder abduction (0°–180°) in the frontal plane. Systematically, upward motion and downward motion each had to last 5 seconds (clock measurement). If an abnormality occurred, then the assessors ticked where appropriate on a standardized scoring form. If an assessor was unsure whether an abnormality had occurred, the position of the scapula was scored as normal.

Acromial Distance

The measurement of the distance between the posterior border of the acromion and the wall was performed with the participant standing with his or her back facing the wall. First, the assessor instructed the participant to put his or her feet and thorax against the wall and to stand relaxed. For both shoulders, the assessor measured the distance horizontally between the most posterior aspect of the posterior border of the acromion and the wall with a sliding caliper (Manutan NV, Brussels, Belgium) that had an accuracy of 0.03 mm (Figure 4). Second, the assessor instructed the participant to actively move both shoulders toward the wall while keeping the thorax fixed against the wall, and he or she measured the distance again.

Figure 6. Modified lateral scapular slide test: arms abducted to 180° in the frontal plane without extra load.

Table 2. Interobserver Reliability of Visual Observation of Scapular Positioning Including All Scapular Deviations (N = 60)

Scapular Positioning	κ
At rest	0.41[a]
During unloaded abduction to 180°	0.63[b]
During loaded abduction to 180°	0.36

[a] Indicates moderate agreement.
[b] Indicates substantial agreement.

Modified LSST

Because the muscular system is the major contributor of scapular mobility and stability[1,2] and because scapular positioning abnormalities can occur above 90° of humeral abduction,[31] we modified the LSST to include 2 static positions performed bilaterally: 90° of humeral abduction in the frontal plane with a 1-kg load and 180° of humeral abduction in the frontal plane (Figures 5 and 6). We instructed the participants to fix their eyes on an object in the examination area so they would maintain a fixed posture during the measurement.[29] We used a metal tape measure to note the distance between the inferior angle of the scapula and the closest spinous process in the same horizontal plane. Between positions, we instructed the participants to keep their arms relaxed at the sides.

Statistical Analysis

All data were analyzed using SPSS (version 12.0 for Windows; SPSS Inc, Chicago, IL). A 1-sample Kolmogorov-Smirnov goodness-of-fit test was used to identify normal distribution ($P > .05$; data not shown). To calculate the interobserver reliability of numeric data, a 2-way mixed-effect model intraclass correlation coefficient (ICC) (3,2) was used.[40] For interpretation of the ICCs, reliability coefficients of less than 0.50 indicated poor reliability; reliability coefficients ranging from 0.50 to 0.75 indicated moderate reliability; and reliability coefficients of greater than 0.75 indicated good reliability, with values greater than 0.90 ensuring excellent reliability.[41] For most clinical measurements, ICC values greater than 0.90 are needed to ensure reasonable reliability.[41] To calculate the interobserver reliability of nominal data, the κ value was used. In interpreting κ, values less than 0.19 indicated poor agreement; values from 0.20 to 0.39 indicated fair agreement; values from 0.40 to 0.59 indicated moderate agreement; values from 0.60 to 0.79 indicated substantial agreement; and values greater than or equal to 0.80 indicated almost perfect agreement.[42] The SEM ($SD \times \sqrt{1-ICC}$) and the minimal detectable change score with 95% confidence bounds (MDC95) were calculated as the average $SEM \times 1.96 \times \sqrt{2}$.[20,22,43]

RESULTS

Visual Observation

Results of the interobserver reliability of the observation at rest, during unloaded movement, and with a 1-kg load are presented in Table 2. The highest value of agreement ($\kappa = 0.63$) was attained during unloaded movement.

Table 3 shows the reliability data of the observation of scapular positioning for the presence of each movement pattern separately. Both assessors rated 29 shoulders (48%) as demonstrating no winging and 20 shoulders (33%) as demonstrating an abnormal winging pattern. The assessors made similar judgments about the presence of winging in 53 shoulders (88%, $\kappa = 0.78$). The observation of protraction, elevation, or rotation of the scapula was not reliable ($\kappa \leq 0.1$).

Acromial Distance

The reliability data of the 2 clinical tests for assessment of scapular positioning are presented in Table 4. The interobserver ICCs of the measurement of the distance between the posterior border of the acromion and the wall at rest and during active shoulder retraction were 0.72 and 0.75, respectively (Table 5). Table 5 also presents the SEMs and MDC95s for both clinical tools.

Modified LSST

For the measurement of the modified LSST, the ICCs were 0.63 for 90° of humeral abduction with a 1-kg load and 0.58 for end-range humeral abduction (Table 5). Compared with the other measurements, the modified LSST appeared to be the hardest measure for which to attain reliability, with low ICCs and the highest SEMs and MDC95s.

DISCUSSION

Our primary interest was the reliability of a standardized observation protocol and 2 clinical tests for the assessment of scapular positioning and movement in healthy musicians. Our results demonstrated that visual observation of the scapula is a reliable tool for screening prominence of the medial scapular border (winging) and prominence of the inferior scapular angle (tilting) during unloaded movement in healthy musicians. We found that interobserver reliability was higher during unloaded movement ($\kappa = 0.63$) than at rest ($\kappa = 0.41$). Poor reliability in other elements of the observation protocol may have resulted from the low variance in the study population. As suggested, a 1-kg load would influence functional muscular

Table 3. Interobserver Reliability for the Observation of Tilting, Winging, Elevation, Protraction, and Rotation (N = 60)

	Scapular Deviation				
	Tilting	Winging	Elevation	Protraction	Rotation
At rest, κ	0.48[a]	0.42[a]	−0.1	−0.05	NA
During unloaded abduction to 180°, κ	0.52[a]	0.78[b]	0.1	−0.06	−0.05
During loaded abduction to 180°, κ	0.24	0.50[a]	0.05	−0.05	−0.05

Abbreviation: NA, not applicable.
[a] Indicates moderate agreement.
[b] Indicates substantial agreement.

Table 4. The Outcomes of the 2 Clinical Tests for the Assessment of Scapular Positioning (N = 60)

Test		Assessor 1		Assessor 2	
		Mean ± SD, cm	Range, cm	Mean ± SD, cm	Range, cm
Acromial distance	Shoulders relaxed	7.0 ± 1.7	3.2–10.0	7.9 ± 1.7	3.7–10.8
	Shoulders retracted	4.0 ± 1.4	1.6–8.0	4.3 ± 1.6	1.4–8.4
Lateral scapular slide test	90° of humeral elevation with a 1-kg load	11.4 ± 1.2	9.2–10.8	10.5 ± 2.0	7.2–16.6
	180° of humeral elevation	14.9 ± 1.7	11.9–18.1	16.4 ± 1.3	13.5–20.5

activity and, thus, scapular positioning, making abnormal positioning patterns more visible. However, adding a weight to influence muscle fatigue did not increase reliability. In fact, reliability of visual observation decreased when a 1-kg load was added ($\kappa = 0.36$). It is possible that muscle contraction during loaded activity made the palpation and observation of the bone marks of the scapula more difficult. The question is, "Could a 1-kg load really lead to muscle fatigue in young, healthy musicians?"

The amount of subcutaneous fat on a particular musician could also influence accuracy of observation and palpation. The participants in our study had a mean body mass index of 20.2 ± 1.9 kg/m^2, which indicates that the observation was not obscured by subcutaneous fat. As noted, Kibler et al[23] studied the reliability of qualitative clinical evaluation of scapular dysfunction and found moderate agreement between observers. However, these authors used only static video recordings. The authors[23] indicated that videotape is never as accurate as actual visualization. Because of the 3-dimensional character of scapular motion, multiple viewing angles cannot be evaluated using 1 camera. A dynamic evaluation can enhance reliability, so we included both dynamic and in vivo evaluation. We observed the highest interobserver reliability outcomes during unloaded movement, which emphasizes the usefulness of dynamic evaluation in screening healthy musicians. It is unclear from our study how the clinical experience and training of the observers influenced the observation of static and dynamic scapular positioning patterns. Given the poor reliability of the observation of lateral translation of the inferior angle (upward rotation), elevation, and protraction, classifying the scapula as *dysfunctional* versus *nondysfunctional* may have resulted in higher reliability. However, the low variance in these observational factors in this population was probably a major issue, which resulted in poor reliability data. Thus, to achieve higher reliability, a more detailed description of elevation, depression, protraction, and upward rotation of the scapula together with greater participant variance is necessary.

We measured scapular protraction using the acromial distance between the posterior border of the acromion and the wall at rest and during active retraction. This test displayed moderate interobserver reliability. Nijs et al[1] examined the interobserver reliability of scapular protraction in the supine position, which appeared to have higher reliability (all ICCs > 0.88) than in individuals who were in a standing position. In the standing position, the scapula is pulled forward in a more protracted position. However, in both the relaxed and retracted positions, the mean distance between the posterior border of the acromion and the table[1] was greater than the mean distance between the posterior border of the acromion and the wall in our study. First, the soft surface of the examining table could have had a denting effect during measurement. Second, Nijs et al[1] included participants with shoulder impingement syndrome, whereas we included only healthy participants. Individuals with shoulder impingement syndrome could demonstrate more shoulder protraction.[9,25] Third, we used a sliding caliper instead of a tape measure.[1] Because participants were positioned differently, we could not identify the solitary effect of the sliding caliper. The position of the scapula at rest is mainly defined by the shape of the thorax and, thus, is influenced by the overall posture of the individual.[44] The amount of body sway during measurement is probably a barrier for establishing good reliability and validity. Peterson et al[24] achieved high intrarater reliability when using the Baylor square technique (distance from the C7 spinous process to the anterior tip of the acromion process) (ICC = 0.91) and the double square technique (ICC = 0.89). In addition, they found a strong correlation between the Baylor square and radiographic measurements. Although radiographic measurements are not the criterion standard, the use of the Baylor square may be a good alternative for the measurement of the acromial distance.

The interobserver reliability of the modified LSST was moderate. The ICCs were 0.63 for 90° of humeral abduction with a 1-kg load and 0.58 for 180° of humeral abduction with high MCD95s and SEMs (Table 5). The SEM values varied from 1.18 cm to 1.85 cm; these values

Table 5. Interobserver Reliability of 2 Clinical Tests for the Assessment of Scapular Positioning (N = 60)

Test		Intraclass Correlation Coefficient[a]	SEM, cm	Minimal Detectable Change with 95% Confidence Interval, cm
Acromial distance	Shoulders relaxed	0.72	1.7	4.71
	Shoulders retracted	0.75	1.36	3.77
Lateral scapular slide test	90° of humeral elevation with a 1-kg load	0.63	1.85	5.13
	180° of humeral elevation	0.58	1.18	3.27

[a] All values indicate moderate reliability.

were slightly higher than the SEM values that Odom et al[29] attained with the standard LSST (range, 0.79–1.2 cm). The SEM and MDC95 may provide a clinical standard relative to values obtained in practice.[20] Although the SEM is an estimate of error that is used to interpret an individual's test score, it also is used to calculate the MDC. The MDC95 indicated that a change of a given magnitude has a 95% probability of being greater than the measurement error associated with repeated measures. Minimal detectable change values reflect a clinically important change in score with the modified LSST and the likelihood that true change has occurred (eg, the MDC95 is the minimum number of centimeters by which the modified LSST must change for the clinician to be 95% confident that a true change has occurred).

We designed the first position from the perspective that a 1-kg load would influence scapular positioning. It is unclear from our study whether a 1-kg load in 90° of humeral abduction influenced reliability. Reliability of the LSST without the 1-kg load presented considerably higher ICCs (>0.70).[1] Taken together with the findings of authors who have already questioned the use of the LSST, we also suggest that this modified version of the LSST should not be used to screen healthy musicians. Study of the LSST with the use of heavier loads and in specific sports is still warranted.

As mentioned, visual observation is often the first step in assessing scapular positioning. This aspect of our standardized observation protocol showed the highest reliability, emphasizing the usefulness of dynamic evaluation in screening healthy musicians. This can help the clinician identify movement faults of the scapula during observation and even during retraining programs. However, these data were only gathered from healthy participants. Therefore, the use of this clinical assessment tool remains limited to screening healthy musicians and the development of preventive exercise programs.

CONCLUSIONS

Our results demonstrated that the modified LSST should not be used to reliably assess scapular positioning. Our data indicated that scapular observation in the relaxed position and during unloaded abduction in the frontal plane is a reliable assessment tool. In addition, the reliability of the measurement of the distance between the posterior border of the acromion and the wall was moderate in healthy musicians. Based on our results, conclusions cannot be generalized to patients with shoulder disorders. Further study of the reliability in people with shoulder pain is warranted. In addition, our study provided interobserver reliability data, but intraobserver data were unavailable. Thus, an intraobserver reliability study is warranted as well. Ultimately, these methods of measuring scapular motion should be validated.

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