Journal of Athletic Training 2011:46(4):438–444

www.nata.org/jat

Lateral Scapular Slide Test and Scapular Mobility in Volleyball Players

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Context: The stability of the scapula in relation to the entire moving upper extremity is the key in the throwing sequence. The importance of scapular positioning in volleyball players has been well documented in the literature, but no one has compared scapular positioning between volleyball players and sedentary people.

Objective: To compare measurements of scapular mobility obtained using the lateral scapular slide test between volleyball players and sedentary participants without shoulder impairments and to compare changes in scapular mobility in players according to the number of years of sport participation.

Design: Cross-sectional study.

Setting: University research laboratory.

Patients or Other Participants: A total of 121 people at a single university volunteered. Of these, 67 were sedentary (age = 24.3 ± 2.34 years, height = 1.69 ± 0.09 m, mass = 65.1 ± 11.91 kg); 54 were volleyball players from 4 professional teams and were separated into 2 groups according to their years of sport participation. The first group was named *young players* (n = 31; age = 17.7 ± 2.58 years, height = 1.83 ± 0.10 m, mass = 68.3 ± 12.21 kg, sport participation ≤ 9 years), and the second group was named *old players* (n = 23; age = 26.9 ± 3.39 years, height = 1.95 ± 4.38 m, mass = 90.7 ± 5.75 kg, sport participation ≥ 10 years).

Main Outcome Measure(s): Study participants completed a rating scale for pain and a questionnaire about demographic and shoulder problems. One assessor performed the lateral scapular slide test and additional flexibility measurements around the shoulder girdle. Flexibility (external rotation, internal rotation) and scapular position (1, 2, 3) were compared among groups (young players, old players, sedentary people) and between sides (dominant, nondominant).

Results: In sedentary participants, we found differences for position 1 ($t_{66} = 3.327$, $P = .002$), position 2 ($t_{66} = 2.491$, $P = .004$), position 3 ($t_{66} = 2.512$, $P = .006$), and internal rotation ($t_{66} = 2.592$, $P = .001$) between the dominant and nondominant sides. In old players, we found differences for position 2 between the dominant and nondominant sides ($t_{22} = 2.956$, $P = .004$). For position 2 ($F_{2,118} = 4.265$, $P = .02$) and position 3 ($F_{2,118} = 4.702$, $P = .01$), we found differences between young and old players. For internal rotation, we found differences between sedentary and old players ($F_{2,118} = 6.578$, $P = .002$) and between young and old players ($F_{2,118} = 3.723$, $P = .01$).

Conclusions: Clinicians evaluating overhead athletes need to remember that asymmetric scapular posture between the dominant and nondominant sides in unilateral overhead athletes might be normal and not necessarily related to injury.

Key Words: upper extremity, shoulder, internal rotation

Key Points

- Measurements obtained with the lateral scapular slide test cannot be used to assess the presence or magnitude of scapular asymmetry.
- Clinicians evaluating overhead athletes must remember that asymmetric scapular posture between the dominant and nondominant sides in unilateral overhead athletes might be normal and might not be related to injury.

In throwing and serving, the scapula facilitates shoulder function by achieving appropriate motions and positions. Optimal function is achieved when normal anatomy interacts with normal physiology to create normal biomechanics. Almost all throwing and serving activities occur with a humerus-to-spine angle of 85° to 100° of abduction.[1] The scapula must rotate to clear the acromion from the rotator cuff to decrease impingement and coracoacromial arch compression. Therefore, the stability of the scapula in relation to the entire moving upper extremity is paramount in the throwing sequence.[1]

Several methods have been 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. Kibler[1] designed the lateral scapular slide test (LSST) to assess scapular asymmetry under varying loads. It is used to determine scapular position with the upper extremity abducted to 0°, 45°, and 90° in the coronal plane. Some authors[2,3] suggested that measurements of scapular positioning based on the difference in side-to-side scapular distance measurements are not reliable and that the LSST should not be used to screen for shoulder dysfunction. Assessment of scapular position is based on the difference between bilateral scapular distances. Kibler et al[1] proposed using the LSST 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[1,4] performed the LSST in studies to assess the ability of the scapular stabilizers to control the scapula under varying load positions. Test positions 2 and 3 placed the shoulder in various degrees of medial (internal) rotation and abduction, and Kibler[1,4] noted that they required activity of the upper and lower trapezius muscles and the serratus anterior muscle, thereby challenging the scapular stabilizers. According to him, the LSST measures the ability of the posterior shoulder muscles to stabilize and position the scapula. Kibler[4] 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 lesions. In athletes with symptoms of shoulder lesions, he noted that a difference of more than 1.0 cm in side-to-side measurements of scapular distance was associated with the presence of shoulder lesions or microtrauma, pain, and decreased shoulder function.[4] Kibler[1] has since 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[1] contended that the injured side should exhibit a greater scapular distance than the uninjured side.

Kibler[1] reported that the test-retest (intratester) ratio of LSST ranges from 0.84 to 0.88 and that the intertester reliability ranges from 0.77 to 0.85, depending on the position, and he suggested that LSST is reliable in terms of reproducibility. Although they reported high intraclass correlation coefficients (ICCs) for intrarater reliability (ICC = 0.81–0.95) using Kibler's protocol, Gibson et al[5] reported that differences between examiners might account in part for their low ICCs for interrater reliability (ICC = 0.18–0.69). However, their use of a modified version of Kibler's protocol also might have accounted for their low interrater reliability. Gibson et al[5] standardized the landmarks and measured the scapular distance from the inferior angle of the scapula to the spinous process of T8.

Assessing scapular mobility by using LSST and flexibility, including active internal and external rotation patterns, is important. The shoulder rotation range of motion of the dominant upper extremity in highly skilled volleyball athletes is shifted toward a more external and less internal rotation position than the nondominant upper extremity. Furthermore, researchers[6–9] using Kibler's studies to investigate young tennis and baseball players indicated that the first change that occurs in an athlete's dominant upper extremity is inflexibility in internal rotation.

The effect of years of sport participation on sport injuries has not been well documented. Kujala et al[10] determined the acute injury profiles of 6 sports and compared the injury rates among the sports. They found that injury rates were low in athletes less than 15 years of age, whereas athletes aged 20 to 24 years had the highest rates.

The importance of scapular positioning in volleyball players has been well documented.[11–16] However, comparison of these players with sedentary people has not received much attention. Using the LSST as an assessment tool appears to have some merit, but to our knowledge no one has compared the scapular mobility of sedentary people and professional volleyball players or has identified changes that occur in scapular mobility with volleyball play. Therefore, the purpose of our study was to compare measurements of scapular mobility obtained using the LSST between sedentary people and professional volleyball players without shoulder impairments and to compare changes in scapular mobility in players according to the number of years of sport participation.

METHODS

Participants

Of the 121 people from 1 university who volunteered for participation, 54 (46 men, 8 women) were competitive volleyball players (Table 1). We defined *competitive players* as athletes who were included on a volleyball team and were actively playing volleyball at the time of the study. Four players reported shoulder pain, and 50 had no history of shoulder pain. Volleyball players also were separated into 2 groups according to the number of years of sport participation. The first group was named *young players* (≤ 9 years of sport participation), and the second group was named *old players* (≥10 years of sport participation). The remaining 67 volunteers (30 men, 37 women) were healthy, sedentary people who participated as the third group (Table 1). We defined *sedentary participants* as people who had not been participating in any sports. Three of the participants had a history of impingement. All assessment variables were recorded for the dominant and nondominant sides of the participants. We defined *dominant* as the upper extremity with which a person would hit a ball.

Inclusion criteria were the ability to actively perform pain-free abduction from 0° to 45° and from 0° to 90° in elbow extension and age greater than 15 years. Exclusion criteria were shoulder injury, shoulder surgery in the 2 years before the study, systemic pathologic condition, or intervention in the 3 months before the study, including corticosteroid or hydrodilatation injection or physiotherapy. Specifically, *injury* included shoulder pain in active abduction or external rotation for more than 3 months, a reason to suspect a complete rotator cuff tear (eg, substantial shoulder weakness), a positive drop-arm sign or previous fracture, or a high-riding humerus observed on plain radiographs. Systemic pathologic conditions included inflammatory joint disease, complex regional pain syndrome, and shoulder pain referred from vertebral structures that was diagnosed via spinal clearing tests.

All participants were interviewed with a standardized assessment form that included questions about the severity of pain in the shoulder, neck, and thoracic regions and previous injuries. All participants and the team coaches of minors provided written informed consent, and the Hacettepe University

Table 1. Descriptive Statistics of Participants (Mean ± SD)

Group	Age, y	Height, m	Mass, kg	Body Mass Index, kg/m^2
Sedentary (n = 67)	24.3 ± 2.34	1.69 ± 0.09	65.1 ± 11.91	22.79 ± 2.60
Young players (n = 31)	17.7 ± 2.58	1.83 ± 0.10	68.3 ± 12.21	20.39 ± 5.59
Old players (n = 23)	26.9 ± 3.39	1.95 ± 0.04	90.7 ± 5.75	23.85 ± 3.10
Total (N = 121)	20.29 ± 4.22	1.86 ± 0.13	73.7 ± 14.72	21.3 ± 4.40

Ethical Research Committee (approval code HEK 09/235, July 2, 2009) approved the study.

Data Collection

Participants rated the severity of their pain on an 11-point pain rating scale, with 0 representing *no pain* and 10 representing *the worst pain possible*.[17,18] The reliability of the rating scale has been reported to range from 0.67 to 0.96, and the validity has been determined to range from 0.79 to 0.95.[18] Before testing, participants were disrobed so that the spine and both scapulae were in full view of the physical therapist. The spinous process closest to the inferior angle of the scapula was identified and marked on each participant by the same investigator (N.O.).

To maintain a consistent posture during the various test positions, participants were instructed to fix their eyes on an object in the examination area. For test position 1 of the LSST, participants were instructed to keep their upper extremities relaxed at their sides (Figure 1). The assessor obtained and confirmed the test position and then identified through palpation and marked the inferior aspect of the inferior angle of the scapula and the closest spinous process in the same horizontal plane. The distance between the 2 reference points was measured bilaterally with a tape measure. This procedure was repeated for test positions 2 and 3. For test position 2, the patient was instructed to actively place both hands on the ipsilateral hips and, consequently, the humerus was positioned in medial rotation at 45° of abduction in the coronal plane (Figure 2). In test position 3, participants were instructed to actively extend both elbows and to elevate and maximally internally rotate ("thumbs down") both upper extremities to 90° in the coronal plane (Figure 3).

We bilaterally measured scapular distance to find the value of the difference in side-to-side measurements. All scapular distance measurements were taken 2 times. The mean was calculated and used for data analysis. The value of the difference between sides was calculated by subtracting the value for the dominant side from the value for the nondominant side, and the absolute value of this difference was used for data analysis. A difference of 1.5 cm or more in any of the 3 positions was considered a positive result of the LSST.

We took additional flexibility measurements around the shoulder girdle, measuring the distance from the tip of the thumb to the cervical spine (C7) behind the neck with the shoulder in maximal external rotation and measuring the distance from the tip of the thumb to the thoracic spine (T5) up the back with the shoulder in maximal internal rotation (Figures 4 and 5). The reliability of the maximal internal rotation measurement was reported to be 0.44 and of maximal external rotation was reported to be 0.39, indicating reasonable reliability.[19,20]

Statistical Analysis

Descriptive results for the measurements of the 3 positions were provided as means and standard deviations. We calculated 2-tailed paired *t* tests to analyze the absolute differences between nondominant and dominant sides among groups. We used parametric 1-way repeated-measures analysis of variance with the dependent variables of flexibility and scapular position and the independent variable of group (sedentary, young players, old players). When we found differences for the overall tests, we used post hoc pairwise contrasts. The α level was set a priori at .05. Data were analyzed with SPSS (version 15; SPSS Inc, Chicago, IL).

Figure 1. Position 1 of the lateral scapular slide test.

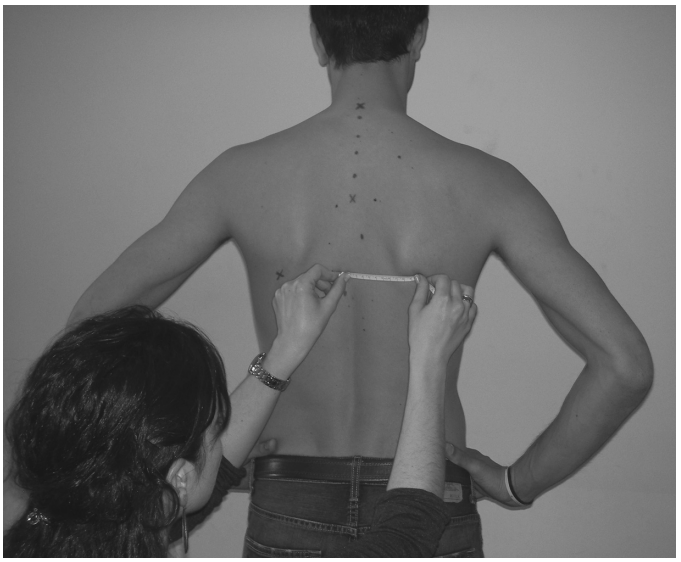

Figure 2. Position 2 of the lateral scapular slide test.

Figure 3. Position 3 of the lateral scapular slide test.

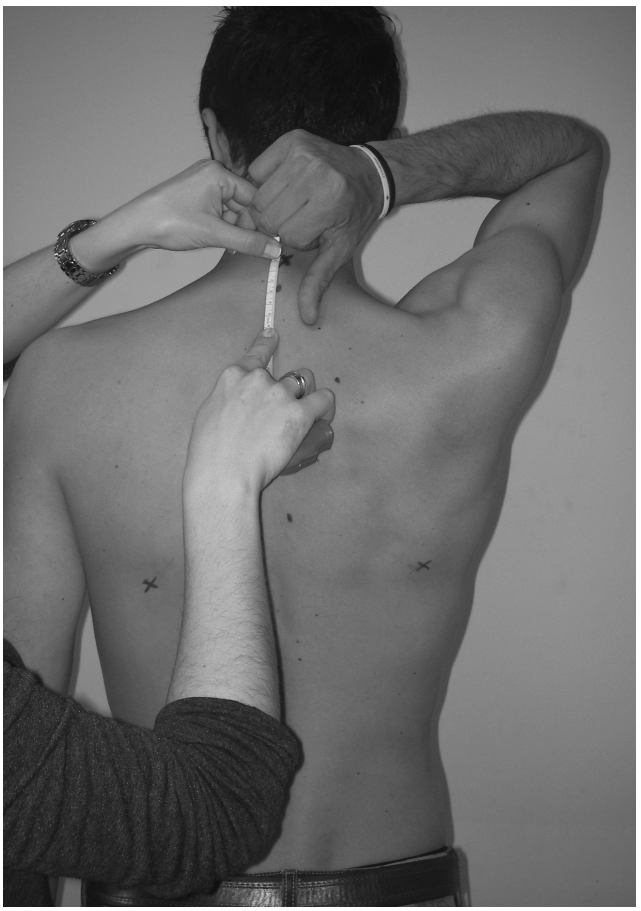

Figure 4. Measurement of active external rotation.

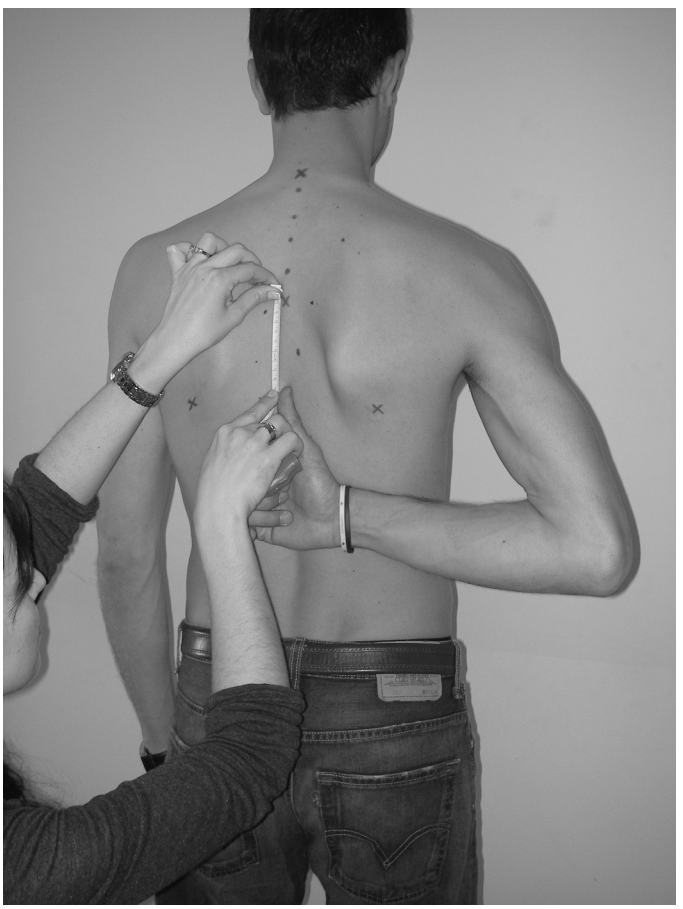

Figure 5. Measurement of active internal rotation.

RESULTS

The results of the LSST are shown in Table 2, and the results of the flexibility tests are shown in Table 3. Most measurements of the 3 positions showed normal distribution. In sedentary participants, we found differences between the dominant and nondominant sides for position 1 ($t_{66}=3.327$, $P=.002$), position 2 ($t_{66}=2.491$, $P=.004$), position 3 ($t_{66}=2.512$, $P=.006$), and internal rotation ($t_{66}=2.592$, $P=.001$). In young players, we found no difference in any of the measured variables ($t_{30}=0.087$, $P=.93$). In old players, we found a difference between dominant and nondominant sides in position 2 ($t_{22}=2.956$, $P=.004$). We found differences for the comparison of dominant and nondominant sides among groups ($F_{2,118}=3.341$, $P=.004$), for position 3 ($F_{2,118}=3.975$, $P=.001$), and for internal rotation ($F_{2,118}=8.616$, $P<.001$). We found differences between young and old players for position 2 ($F_{2,118}=4.265$, $P=.02$) and position 3 ($F_{2,118}=4.702$, $P=.01$). For internal rotation, the differences occurred between sedentary participants and old players ($F_{2,118}=6.578$, $P=.002$) and between young and old players ($F_{2,118}=3.723$, $P=.01$).

DISCUSSION

We investigated the differences among the 3 positions of LSST and flexibility. We frequently observed differences between the dominant and nondominant sides in old players and sedentary participants but not in young players. We found that internal rotation differed between old players and both sedentary participants and young players.

Some researchers have determined that the LSST should not be used to screen for shoulder dysfunction because it is unreliable. However, Kibler[1] found that the LSST is reliable in terms of reproducibility. Gibson et al[5] reported low ICCs for interrater reliability but high ICCs for intrarater reliability for the LSST. Differences among examiners or their use of a modified version of Kibler's protocol might explain their low interrater reliability. In our study, the tester reported differences in scapular position of the dominant and nondominant extremities when using the LSST. Shadmehr et al[3] studied the reliability measurements of LSST at 3 different degrees of shoulder joint abduction and reported that the diagnostic accuracy of the LSST was low, which brings into question the clinical importance of the test's outcomes. With similar findings, we demonstrated that measurements obtained with the LSST cannot be used to assess the presence or magnitude of scapular asymmetry.

As noted, Kibler[4] assumed that the injured side would exhibit a longer scapular distance than the uninjured side with the LSST. Because hypomobility of the shoulder is thought to result in scapular asymmetry and shoulder dysfunction, one problem with the LSST might be the a priori assumption of a unidirectional change in scapular positioning associated with shoulder injuries.

Although such methods can be used to measure the simple linear displacement of the scapula on the thorax, they do not assess scapular motions that involve twisting and rotation, such as tipping or tilting of the scapula about an axis parallel to the scapular spine and winging about a vertical axis. For example, in a 3-dimensional study of scapular orientation, Myers et al[21] showed 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. These changes in scapular positioning are accompanied by changes 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.[22] Ludewig and Cook[23] further demonstrated that, compared with participants without shoulder impairments, patients with symptoms of shoulder impingement exhibited less upward rotation of the scapula and greater anterior tipping and medial rotation, coin-

Table 2. Lateral Scapular Slide Test Results, cm (Mean ± SD)

	Test Position 1			Test Position 2			Test Position 3		
Group	Dominant	Nondominant	Difference[a]	Dominant	Nondominant	Difference[a]	Dominant	Nondominant	Difference[a]
Sedentary (n=67)	0.0±0.0[b]	8.8±1.7[b]	8.4±1.6	0.7±0.6[b]	9.2±1.5[b]	8.8±1.5	0.7±0.6[b]	9.1±1.6[b]	8.9±1.5
Young players (n=31)	0.0±0.0	8.4±1.7	8.3±1.4	0.5±0.6	8.9±1.7	9.0±1.5[b]	0.8±0.8	9.5±1.8	9.3±2.0[b]
Old players (n=23)	0.0±0.0	10.4±1.6	10.0±1.2	0.9±0.7[b]	10.9±1.2[b]	10.6±1.1[b]	0.5±0.6	11.3±1.7	11.0±1.6[b]

[a] We calculated differences for each position and each person and then analyzed those means and SDs. Therefore, the values do not reflect the exact differences between the dominant and nondominant sides.
[b] Indicates difference ($P<.05$).

Table 3. Flexibility Test Results, cm (Mean ± SD)

	Internal Rotation			External Rotation		
Group	Dominant	Nondominant	Difference[a]	Dominant	Nondominant	Difference[a]
Sedentary (n=67)	0.7±0.6[b]	2.6±3.5[b]	1.5±3.6[b]	2.2±1.9	8.4±2.9	7.5±3.0
Young players (n=31)	0.5±0.7	5.1±5.3	5.8±6.4[b]	2.8±2.6	9.1±3.1	8.9±3.7
Old players (n=23)	1.0±0.7	5.7±4.2	3.6±2.8[b]	4.5±2.6	7.7±3.1	8.5±3.0

[a] We calculated differences for each position and each person and then analyzed those means and SDs. Therefore, the values do not reflect the exact differences between the dominant and nondominant sides.
[b] Indicates difference ($P<.05$).

ciding with changes 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 are not used routinely in the clinic and have not been shown to be useful in clinical practice. Moreover, the relationship between simple linear measures and more complex 3-dimensional measures has not 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.[21,22]

In highly skilled volleyball athletes, shoulder rotation range of motion is in a more external and less internal rotation position in the dominant than the nondominant upper extremity. Furthermore, researchers[6–9] indicated that inflexibility in internal rotation is the first change to occur in the athlete's dominant upper extremity. We found that the flexibilities of internal rotator muscles varied between volleyball players and sedentary participants. Volleyball has positive effects, mainly on the internal rotator muscles of the shoulder stabilizers. Old players were found to differ in terms of internal rotation. As the number of years of sport participation increases, overuse deformities and nerve entrapment neuropathies are thought to cause this situation.[24]

Burkhart et al[25] reported that injured overhead athletes typically present with an asymmetrically dropped shoulder on the affected side, caused by increased scapular protraction, anterior tilting, and internal rotation. This pattern is similar to the scapular asymmetry we found in healthy overhead athletes. Our findings suggested that the asymmetry found in old players might not necessarily be related to an abnormality. A pathologic threshold at which an asymmetric scapular posture becomes problematic might exist. However, these possibilities cannot be confirmed without comparing resting asymmetric scapular posture between healthy and injured overhead athletes. Decreased scapular upward rotation and increased protraction, internal rotation, and anterior tipping on the injured side (the dominant side in most cases) commonly are found in patients with various shoulder conditions.

Clinically, separating the posterior capsule from the posterior rotator cuff musculature (infraspinatus and teres major) is extremely difficult. Considering the position of abduction and maximal horizontal adduction used during this examination, one can reasonably assume that both the posterior capsule and the posterior rotator cuff play roles in limiting cross-body humeral motion.[26] Anatomic studies are needed to elucidate the role of the various posterior shoulder structures in limiting horizontal adduction.

Research into the effect of years of sport participation on sport injuries is limited. Kujala et al[10] found low injury rates in athletes aged less than 15 years and the highest rates in athletes aged 20 to 24 years. Therefore, we included only participants who were more than 15 years of age so we could determine the effects of volleyball on scapular positioning and shoulder function.

In terms of mobility and flexibility, scapular mobility between dominant and nondominant sides was different in sedentary people but was not different in young players who had participated for approximately 5 sport years. The reasons for this lack of difference are that in these athletes, the shoulder joint provides proper mobility and flexibility, and scapular deformities due to overuse in sport have not developed.

Further investigation is needed to examine the relationship between upward rotation asymmetry and shoulder abnormalities. The scapular asymmetry about each rotation axis was small, which might be why researchers who used 2-dimensional measuring methods, such as a tape measure or an inclinometer, were unable to detect asymmetry. The asymmetric appearance of the scapula might result from the combined effect of the rotations about multiple axes.

As a limitation, we found that the LSST was not a good method for identifying shoulder impairment. The inability of the LSST to help detect diagnosed shoulder impairment is consistent with findings of previous investigators[7] who did not find a relationship among scapular positioning, muscle performance, and shoulder dysfunction.

Clinicians evaluating overhead athletes need to keep in mind that some degree of asymmetry with resting scapular posture might be present in the shoulders of healthy overhead athletes.[27–29] Measuring scapular posture after the athlete is injured will not allow the clinician to determine whether the asymmetry is a normal adaptation that existed before the injury or an abnormal change associated with the injury. Therefore, measuring baseline scapular posture before preseason training, so it can be compared with measurements of scapular posture at the time of injury, might help identify any abnormal asymmetry related to the injury.

Although the healthy overhead athletes displayed asymmetric scapular posture, the differences we found between the dominant and nondominant shoulders were small. Therefore, our results must be used with caution, and further investigation is warranted. In addition, resting scapular posture is a static measurement and might not reflect scapular kinematics during functional movements. Thus, when evaluating athletes with shoulder injuries, clinicians need to assess both resting scapular posture and dynamic scapular kinematics.

Assessing shoulder posture asymmetry in nonoverhead athletes and overhead athletes with various shoulder abnormalities might reveal useful information about the postural changes associated with participation in overhead sports and with shoulder conditions. Furthermore, obtaining baseline evaluation of scapular asymmetry and prospectively studying shoulder injuries will provide valuable information about the possible cause-and-effect relationship between resting scapular posture and injury.

CONCLUSIONS

We demonstrated that measurements obtained with the LSST cannot be used to assess the presence or magnitude of scapular asymmetry. Clinicians evaluating overhead athletes need to keep in mind that asymmetric scapular posture between the dominant and nondominant sides in unilateral overhead athletes might be normal and might not necessarily be related to injury. Our results emphasized the importance of baseline evaluation of the scapular posture in overhead athletes for the accurate assessment of scapular asymmetry after injury. In the future, researchers should reexamine reliability of these methods and measure participants with shoulder conditions.

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