This was the third research meeting focused on scapular function and dysfunction, following similar meetings in 2003 and 2006. The purpose of this meeting, hosted by the Shoulder Center of Kentucky, was to continue to examine the biomechanical and clinical factors thought to be associated with the role of the scapula in shoulder function and dysfunction. Since the last Summit, much more information has been created in this area, and it was thought that enough progress had been made that an organized overview of current knowledge could provide some consensus statements to guide further research and provide assessment and treatment guidelines.

A call for abstracts was extended to researchers with proven interest and published research on the scapula. They were asked to present their current research and to participate in the consensus process. The 17 participants came from the United States, Belgium, and the United Kingdom. They included physicians, physical therapists, certified athletic trainers, and occupational therapists.

The meeting was organized around 3 primary categories of information: scapular kinematics and dysfunction, clinical evaluation of the scapula, and interventions. The format of the meeting included 20-minute podium presentations based on the submitted abstracts and group discussions of the presentations within each category.

The last session of the meeting involved development of consensus statements for each category. Each consensus statement was developed to present a summary of what is known within each category, what is not known but is thought to be important in that category, and suggested strategies to improve knowledge and clinical application in that category.

This document represents the current state of knowledge concerning the aspects of scapular function and dysfunction discussed at the Summit. It is expected that, as more knowledge is developed, the gaps will be filled in and a clearer understanding of the roles of the scapula in shoulder function and dysfunction will emerge.
Scapular Summit 2009: Consensus Statements

Consensus Statements

Scapular Kinematics in Shoulder Function and Dysfunction

What do we know?
1. During normal elevation of the arm overhead, scapulothoracic motion is primarily upward rotation and secondarily posterior tilting. Internal/external rotation is minimal prior to 100° of humerothoracic elevation.43,49
2. Differences in scapular kinematics across planes of elevation in healthy subjects are minimal and occur primarily in the transverse plane (clavicle retraction, scapular internal rotation).43,49
3. During normal elevation of the arm, the sternoclavicular (SC) joint (clavicle relative to the thorax) primarily rotates posteriorly, secondarily retracts, and undergoes minimal elevation.43,62
4. During normal elevation of the arm, the acromioclavicular (AC) joint (scapula relative to the clavicle) primarily posteriorly tilts, secondarily upwardly rotates, and internally rotates.39,61
5. During normal elevation of the arm overhead, both the SC and AC joints contribute to scapulothoracic upward rotation, while SC retraction and AC internal rotation are offsetting motions. Scapulothoracic posterior tilting is predominately an AC joint motion, with a small contribution from SC posterior rotation.43,67
6. Scapular kinematic changes can occur over the course of a professional pitching season.68
7. Decreased horizontal adduction range of motion is associated with increased scapular “protraction” (anterior positioning of the acromion) in baseball players.35
8. Baseball players have more scapular protraction in their dominant arm compared to the nondominant arm.35
9. Pitchers dominant arm demonstrates more scapular protraction than position players.35
10. Minimal acromiohumeral distance is not equivalent with rotator cuff tendon proximity to the acromion. The rotator cuff tendons are in closest proximity to the undersurface of the acromion earlier in the range of motion (40°-60° humerothoracic elevation).45,47 The minimal acromiohumeral distance occurs near 90° humerothoracic elevation.2,24,42
11. Proximity of the rotator cuff tendons to the glenoid (potential internal impingement) can occur at higher ranges of elevation (120° and above), not only with combined abduction/external rotation.42,57
12. Fatigue of shoulder muscles changes scapular kinematics and is task specific.5,20,21,70,72 These changes in scapular kinematics can persist after the fatigue task.10,71

What are important gaps in our knowledge?
1. Understanding what structures (if any) are being “impinged” to produce impingement symptoms.
2. Understanding the mechanisms of internal versus subacromial impingement.
3. Understanding how osseous or soft tissue changes influence proximity of the rotator cuff tendons to the coracoacromial arch or glenoid-labral complex.
4. Understanding what is the influence of the coracoacromial ligament deformation and contact in subacromial impingement.77
5. Understanding how scapular kinematic changes do or do not relate to impingement mechanisms and pain.
6. Understanding whether apparent scapular kinematic changes are causative and/or compensatory.
7. Understanding why some patients seem to compensate and some do not.
8. Better understanding the window of normal scapular kinematics, inside which small scapular kinematic changes for an individual are insignificant.

Where do we go from here?
1. Potential development of normal profiles or a window of scapular kinematics outside of which changes are of clinically meaningful magnitude.
2. Measurement of soft-tissue position, compression, deformation, or tension with impingement symptoms and impingement tests.
3. Distinguishing internal versus subacromial impingement subgroups when measuring 3-dimensional scapular kinematics in patients.
4. There are multiple studies demonstrating small kinematic differences between patients with pathologies (impingement, instability, adhesive capsulitis); however, there are conflicting findings and considerable variation in which motions are affected. Therefore, the relationship between scapular dysfunction and specific pathoanatomical structures and injury is unclear.
5. Investigating the influence of osseous and soft tissue
changes on scapular mechanics and rotator cuff tendon proximity.
7. Measurement of coracoacromial ligament deformation during normal shoulder motion.
8. Can fatigue be induced as a “provocative test” to magnify scapular kinematic alterations?
9. What is causing the scapular kinematic alterations following a fatiguing task?

Consensus Statement
Participants agreed that the scapula plays a key role in shoulder and arm function as a stable base for optimal muscle activation, a congruent socket for ball-and-socket kinematics, and as a transfer link for developed forces in the kinetic chain. Optimal scapular kinematics and normal shoulder function require normal clavicular function with contributions from SC joint motion, normal clavicle length and anatomical contour, and AC joint motion; task-specific muscle activation patterns involving multiple muscles around the shoulder girdle; and flexibility of various soft tissues. Because soft tissue length seems highly adaptable, responding to altered patterns of shoulder use, episodic evaluation in athletes is necessary to delineate the current status of the soft tissue.

Information is less clear regarding the precise role that alteration of optimal scapular kinematics (termed scapular dyskinesis) plays in patients with shoulder dysfunction, despite the known association of scapular dyskinesis with many shoulder problems. The latest shoulder kinematic data cast doubt on the conventional theory of subacromial impingement in terms of where in the arc of motion the tendon is closest to the bone. Limited data suggest that internal impingement of the undersurface of the rotator cuff on the glenoid may be occurring in the pain producing arcs of motion seen clinically. Three major areas need to be better defined: (1) the role of bony or soft tissue changes on scapular dyskinesis, (2) how scapular dyskinesis relates to impingement symptoms or other shoulder pathology, and (3) whether scapular dyskinesis is causative or compensatory in shoulder dysfunction.

Clinical Examination
What do we know?
The basic purposes of physical examination were discussed, and there was general agreement that the goal of examination of the scapula is to identify the presence or absence of dyskinesis in the symptomatic patient, guide treatment, and inform prognosis. While many studies have identified tests and measures that can be performed reliably, very few have been shown to be clinically meaningful (ie, validity) by demonstrating correlations with biomechanical motions, pathology, symptoms, or outcomes.34 Given this serious limitation of the available evidence, what follows are group consensus recommendations for a collection of tests that should be routinely performed as the basic scapular component of a clinical shoulder evaluation, and seem worthy of further study. It was determined that clinical measures of scapular dysfunction could include clinical observation of scapular dyskinesis, clinical tests that alter symptoms, as well as manual muscle testing of periscapular muscles. Other measures believed to be related to scapular dysfunction include neck, thoracic, and shoulder posture, pectoralis minor tightness, and posterior shoulder tightness.

1. Observational Scapular Assessment (Scapular Dyskinesis Test) Visual observation of scapular motion from behind the patient during flexion and abduction to determine if aberrant motion is present. The test consists of characterizing scapular dyskinesis as absent or present with further description of winging (prominence of any portion of the medial scapular border away from the thorax) or dysrhythmia (premature, or excessive, or stuttering motion during elevation or lowering).67 This test, based upon visual observation during flexion and abduction with a weight, demonstrated satisfactory reliability.65 Subjects identified as positive for dyskinesis showed less upward rotation, less clavicle elevation, and less clavicle retraction measured 3-dimensionally. However, scapular dyskinesis was not related to symptoms in a group of athletes engaged in overhead intensive sports66 and has been found to be equally prevalent in patients with shoulder pain and the general population without symptoms.74

2. Symptom Alteration Tests These tests are designed to detect relevant scapula dysfunction in patients with shoulder pathology by determining if shoulder symptoms are changed after manually altering scapular position and motion.

a. Scapular Reposition Test66 The scapula is moved toward posterior tilt and external rotation, while the patient generates an elevation force. This test has demonstrated reliability and has been shown to produce decreased pain and increased strength in a subgroup of overhead athletes, but decreased pain and increased strength were not related.66

b. Scapular Retraction Test67,69 The scapula is passively moved toward posterior tilt and external rotation with slight voluntary retraction. This test is very similar to the scapular reposition test and has been shown to increase elevation strength in patients and healthy subjects.69 This test appears to be altering scapular kinematics by increasing posterior tilt, external rotation, and scapular retraction (defined as the projected angle in the transverse plane formed between the sternum and acromion relative to the frontal plane bisecting the sternal notch) as compared to elevation against resistance without the scapula stabilized.32

c. Scapular Assistance Test67,59 Scapular upward rota-
Scapular Summit 2009: Consensus Statements

1. There is a need for easily implemented clinical tests and measures that quantify and allow accurate identification of scapular dysfunction.

2. There is a need to determine the meaningfulness of scapular dysfunction.
   a. Is it always a problem when we see it or can it be a normal variation?
   b. Is it mainly an alteration in kinematics that may produce or exacerbate shoulder dysfunction as part of a "cascade of injury" involving other shoulder structures or other injuries, similar to a sulcus sign?
   c. Is it a cause or an effect relative to common glenohumeral pathologies?
   d. Are there important subgroups of scapular dysfunction that may need different types of treatment or demonstrate different outcomes?

3. There is a need to determine the relationship between scapular dysfunction and symptoms, disability, and outcome in patients undergoing rehabilitation for common glenohumeral pathologies such as labral tears, impingement and rotator cuff tendinopathy, and glenohumeral instability.

4. There is a need for testing the reliability, validity, and clinical utility of inclinometer measures of scapular position. There are multiple studies demonstrating small kinematic differences between patients with pathologies (impingement, instability, adhesive capsulitis); however, there are conflicting findings and considerable variation.

5. It is unknown whether there is an optimal cluster of scapular tests to best identify a patient as having scapular dysfunction that correlates with symptoms, disability, or outcome.

6. While the concept of pectoralis minor tightness has a strong biomechanical basis for relevance to scapular dysfunction, there is a need for pectoralis minor measures capturing maximal length and excursions.

Where do we go from here?

Posture

While the concept of neck, thoracic, and shoulder resting posture has a biomechanical basis for relevance to shoulder and scapular dysfunction, there are no widely accepted or validated clinical measures to identify a given patient as having an abnormal or poor posture. Current available options include the double-square method to measure forward shoulder posture and various forms of goniometry and inclinometry techniques for neck and thoracic spine posture.

Pectoralis Minor Tightness

While the concept of pectoralis minor tightness has a strong biomechanical basis for relevance to scapular dysfunction, there are no widely accepted or validated clinical measures to identify a given patient as having a tight pectoralis minor muscle. Existing measures primarily capture length at resting posture, not at maximal length.

Posterior Shoulder Tightness

Several studies have documented reliability for measures of posterior shoulder tightness using either glenohumeral internal rotation or horizontal adduction. Shoulder tightness measures are readily susceptible to previous activities, such as baseball pitching. Tightness has been shown to be related to shoulder impingement, and labral tears. Its relationship to scapular dysfunction is less clear but posterior shoulder tightness has been associated with a more protracted scapula and scapular dyskinesis.

There was preliminary evidence presented suggesting that neither a positive scapular dyskinesis test nor a positive scapular reposition test is related to the amount of pain or disability experienced by patients with impingement. Earlier work in overhead athletes also failed to show an association between scapular dyskinesis and shoulder pain. There was preliminary evidence presented suggesting that the initial presence of scapular dyskinesis or a positive scapular reposition test is not predictive of outcome with a standardized rehabilitation program. However, patients who did improve functionally and symptomatically showed a tendency toward abolishing the dyskinesia and having a negative scapular reposition test at discharge.

What are important gaps in our knowledge?

1. It is currently unknown whether physical examination of the scapula may be useful in directing specific types of treatment such as operative versus nonoperative, or directing particular nonoperative interventions such as specific scapular exercise, scapular taping, or bracing.

2. The correlation between positive scapula special tests and symptoms is largely unknown.

3. There are no quantitative measurement techniques that would allow characterization of a given individual as having scapular dyskinesis.

4. Understanding if clinical inclinometer methods can usefully measure 3-dimensional scapular position.

5. It is unknown whether there is an optimal cluster of scapular tests to best identify a patient as having scapular dysfunction that correlates with symptoms, disability, or outcome.

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Where do we go from here?

1. There is a need for easily implemented clinical tests and measures that quantify and allow accurate identification of scapular dysfunction.

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in which motions are affected. Therefore, the relationship between scapular dysfunction and specific pathoanatomical structures and injury is unclear.

**Consensus Statement**
The participants agreed that scapular dyskinesis is frequently associated with shoulder symptoms. However, it is unclear exactly what role dyskinesis plays, and what types of examinations would best demonstrate its presence and its contribution to dysfunction. The general agreement was that dyskinesis is more frequently an impairment, and only rarely the diagnosis implicating injury to a particular structure, relating to a specific joint injury, or specifically dictating a certain treatment. Therefore, clinical evaluation for scapular dyskinesis should emphasize functional implications: the presence or absence of dyskinesis in the symptomatic patient, the effect of correcting dyskinesis on the symptoms, and evaluation of the surrounding anatomic structures that may be implicated in causation of the dyskinesis.

It was agreed that clinical observation of scapular dyskinesis and clinical tests that alter symptoms should form the basis for the scapular evaluation. Other tests of strength and flexibility should complement the basic exam. However, efforts should continue to improve the precision of the tests and to identify subgroups of individuals with dyskinesis who have specific need for treatment.

**Intervention**

**What do we know?**

1. In the presence of various shoulder pathology, scapular muscular impairments can occur, such as alterations in electromyographic signal amplitudes and onset timings.18,25,40,63,75
2. In the presence of impingement symptoms scapular protraction peak torque and relative protraction to retraction forces are reduced.18
3. Some exercises have been identified to activate specific scapular muscles to various levels that can be utilized during rehabilitation in an attempt to reduce impairments.1,11,12,22,26,31,37,45,52,56,64,69
4. Specific stretching exercises have been identified to effectively reduce posterior shoulder tightness46 and lengthen the pectoralis minor in a noninjured population.8,28,53
5. In prescribing scapular muscle rehabilitation exercises consideration should be given to not only amplitude of muscle activity but also relative intermuscle activity, body and joint position, and timing of muscular activation.15,17,41
   a. Varying push-up positions alters relative upper trapezius and serratus anterior muscle activation levels and can be used to emphasize relative activation of these muscles during exercise selection in healthy subjects.41
   b. Healthy subjects have demonstrated that side-lying forward flexion, external rotation, prone horizontal abduction, and prone extension exercises facilitate greater electromyographic signal amplitude of the lower and middle trapezius over the upper trapezius.17
   c. Prone shoulder extension and prone horizontal abduction exercises activate the lower and middle trapezius muscles prior to the upper trapezius.59
   d. Healthy subject are able to alter serratus anterior and lower trapezius muscle activation levels by changing lower extremity position during quadruped exercises.46
   e. Contralateral single-limb stance during dynamic pulling exercise increases lower trapezius muscle activity to the greatest extent.35 These results suggest that lower extremity position and motions can influence shoulder muscular activation levels through the kinetic chain.15
   f. Muscle activation ratios of the upper trapezius to serratus anterior are higher in healthy subjects compared to patients following superior labral anterior-posterior (SLAP) repairs. In prescribing active-assistive range of motion exercises to patients following a SLAP repair, no single active-assistive exercise was found to produce a significantly lower ratio to de-emphasize the upper trapezius.75

6. Therapeutic exercise decreases symptoms and improves function without necessarily altering scapular kinematics displacement.48
7. Clinically observed scapular dyskinesis has demonstrated improvement with a comprehensive therapeutic exercise intervention in patients presenting with symptoms of impingement.50
8. A patient presenting with severe scapular pain following a traumatic event that is recalcitrant to conservative care and has negative magnetic resonance imaging findings could be considered to have a scapular muscle detachment. Following surgical reattachment of the scapular muscle, pain can be dramatically improved.29

**What are important gaps in our knowledge?**

1. Electromyographic studies of therapeutic exercises evaluating body and joint position, scapular muscular activation, and relative timing in activations and recruitment order in patients with shoulder pain and scapular dyskinesis are needed.
2. Should the resolution of scapular dyskinesis become a rehabilitation goal in treating patients with shoulder pain?
3. Do therapeutic exercises or other interventions affect scapular kinematics, scapular muscular performance, or scapular dyskinesis in a positive way in a patient population?
4. Is there a relationship between the resolution of these scapular impairments to outcomes or function?
5. What is the long-term effect of therapeutic exercise on scapular dyskinesis and associated impairments?
6. What is considered balanced scapular muscle activity for particular tasks in healthy and injured populations?
7. If there is a muscular activity imbalance in injured patients, is there a particular timing and group of exercises that should be utilized to restore the imbalance?
8. Can interventions be successful in modifying scapular dyskinesis and preventing shoulder injury?

Where do we go from here?
1. What is the best way to effectively treat scapular dyskinesis?
   a. Do we need specific or general exercise approaches to effectively treat scapular dyskinesis?
   b. Is there a particular dosage response that is needed to reduce scapular dyskinesis?
   c. Is home-based or supervised intervention more effective?
   d. What battery of interventions is most effective at reducing scapular muscle impairments (posterior shoulder tightness, short pectoralis minor, scapular dyskinesis, weak or imbalanced scapular muscles)?
2. What is the duration of symptom reduction, arm function improvement, or scapular dyskinesis restoration following a therapeutic intervention?
3. Does rehabilitation restore normal neuromuscular patterns to improve shoulder scapular muscle function?
4. What is the role of interventions addressing scapular dyskinesis in injury prevention?

Consensus Statement

It was agreed that interventions for scapular dyskinesis need to be based on accurate assessment of the deficits contributing to dyskinesis, understanding the process by which the deficits can be changed, and the ultimate goal of restoration of optimal scapular kinematics.

Most interventions appear to be based on modification of the dynamic soft tissue factors: muscular and capsular flexibility and muscle strength, balance, and patterned activation. Primary surgical interventions are not as common, involving reattachment of medial scapular muscle detachment. Secondary surgical interventions include correction of clavicular damage, or repair of acromioclavicular or glenohumeral joint internal derangement, as a prelude to correction of the soft tissue factors.

It is known that certain types of exercises can increase activation of muscles thought to be key in scapular control, and that exercise can help to activate these muscles in patterns that are theorized to be most efficient for scapular function. The exact role of specific types of rehabilitation interventions is not known, and requires more research. Another area of promising research would be to evaluate the role of conditioning interventions in modifying scapular dyskinesis and to potentially decrease its role in the “cascade to injury.”

REFERENCES


61. Sahara W, Sugamoto K, Murai M, Tanaka H, Yoshikawa H. 3-D kinematic analysis of the acromioclavicular joint during arm abduction using...
**Scapular Kinematics in Shoulder Function and Dysfunction**

**THREE-DIMENSIONAL SC AND AC JOINT CONTRIBUTIONS TO SCAPULAR MOTION ON THE THORAX**

Ludewig PM, Phadke V, Braman JP, Cieminski CJ, LaPrade RF

**STUDY DESIGN:** Controlled laboratory experiment.

**OBJECTIVE:** To describe and compare dynamic 3-D motion of the sternoclavicular (SC) and acromioclavicular (AC) joints during raising the arm, and relate those motions to scapular motion on the thorax.

**BACKGROUND:** The scapula moves on the thorax through combined SC and AC joint motions, yet little data are available on the precise movements occurring at these joints.

**METHODS:** Twelve subjects without shoulder pathology were enrolled. Transcortical pin placement into the clavicle, scapula, and humerus, allowed bone-fixed electromagnetic motion tracking. A surface sensor monitored trunk motion. Subjects completed 2 repetitions of raising the arm in flexion, scapular, and abduction planes. Three-dimensional angles were calculated for SC and AC joints, as well as scapular motion on the thorax. Joint angles were compared between humeral elevation planes using ANOVA.

**RESULTS:** Overall shoulder motion patterns during humeral elevation were clavicular elevation, retraction, and posterior axial rotation at the SC joint; scapular internal rotation, upward rotation, and posterior tilting at the AC joint, and scapular upward rotation and posterior tilting on the thorax. Clavicular posterior rotation (31°) predominated at the SC joint, contributing to scapulothoracic upward rotation. Scapular posterior tilting (19°) predominated at the AC joint, with no substantive contribution of SC motion to scapulothoracic posterior tilting. SC joint retraction and AC joint internal rotation are offsetting motions resulting in minimal scapulothoracic internal/external rotation. Both the SC and AC joints contribute to scapulothoracic upward rotation. Differences between flexion and abduction planes of elevation were largest for transverse plane rotations (retraction and internal/external rotation).

**CONCLUSIONS:** Overall shoulder motion consisted of substantial angular motions at the SC and AC joints enabling the mult关节 interaction required to move and orient the scapula on the thorax. Note: This abstract is based on the following published paper. Ludewig PM, Phadke V, Braman JP, Hassett DR, Cieminski CJ, LaPrade RF. Motion of the shoulder complex during multiplanar humeral elevation. J Bone Joint Surg Am. 2009;91:378-389.

**ADAPTATIONS IN 3-D SCAPULAR KINEMATICS OF PROFESSIONAL BASEBALL PITCHERS OVER 1 SEASON**

Thigpen CA, Reinold MM, Padua DA, Seitz AL, Schneider RE, Gill TJ

**STUDY DESIGN:** Controlled laboratory experiment with pre and post season testing.

**OBJECTIVE:** To examine 3-D scapular kinematics and pectoralis minor length (PML) before and after a season. We hypothesized pitchers would display less upward and external rotation, posterior tilting, and PML concurrent with increased clavicular elevation (ELV) and protraction (PRO) following the season.

**BACKGROUND:** Pitchers have been shown to exhibit alterations in scapular kinematics, however, there is little evidence examining the adaptations that occur in scapular kinematics over the course of a season.

**METHODS:** 3-D scapular kinematics were assessed in 25 (17 right handed; 8 left handed) professional pitchers (mean age, 22 years; height, 189 cm; body mass, 94 kg) during spring training and following their season. All pitchers were asymptomatic and participating without restriction, in all training, practice, and games. An electromagnetic tracking system was used to measure bilateral 3-D scapular angles for upward/downward rotation (U-D), internal-external rotation (IR-ER), anterior-posterior tilting (A-P), ELV, PRO, and PML during 5 repetitions of flexion. PML was determined as the distance from the coracoid process to the 4th intercostal space and normalized to body height (%BH). Preseason measures were taken within 2 weeks of reporting to camp and post-season measures were taken within 4 weeks of the final regular season game. On average, pitchers were assessed 24.5 weeks following preseason assessments. Separate repeated measure analysis of variance (time by side) were used to compare throwing to nonthrowing arm scapular kinematics between the pre and post season measures over the initial position and 90° of flexion (P< .05).

**RESULTS:** There were significant interaction effects for time by angle for U-D (P = .008) and PRO (P = .007). There was also a significant interaction effect (time by side) for U-D (P = .008). There was a significant interaction effect for time by side by angle for IR-ER (P = .03). Post-hoc analysis revealed less UD rotation and PRO at rest concurrent with increased IR at rest and 90° driven by the largest changes on the throwing side. There were no significant interaction effects involving time for AP tilt, ELV, or PML (P>.05). There was a main effect for side for A-P tilt (P = .02) and PML (P = .03) indicating the throwing side was in greater anterior tilt concurrent with a shorter PML before and after the season.

**CONCLUSIONS:** Following 1 season, professional baseball pitchers’ throwing scapula exhibited less upward rotation, clavicular protraction, with increased internal rotation while the nondominant scapula was unaffected. The persistent differences in AP tilt and PML suggests that a shortened pectoralis minor is a potential mechanism affecting the AP tilt. These results suggest scapular adaptations may be a normal occurrence in asymptomatic pitchers due to the chronic, repetitive stresses of pitching. It is unclear if these are protective adaptations or are predisposing factors to injury. Clinicians should carefully consider these potential scapular adaptations while examining injured pitchers, as well as in the development of preventative and rehabilitation programs for baseball pitchers.

**THE RELATIONSHIP BETWEEN SCAPULAR PROTRACTION AND POSTERIOR SHOULDER TIGHTNESS AMONG BASEBALL PLAYERS**

Lauden KG, Moline MT, Meister K

**STUDY DESIGN:** Descriptive laboratory study.

**OBJECTIVE:** To assess the relationship between scapular protraction and posterior shoulder tightness and to determine the amount of scapular protraction among baseball players.

**BACKGROUND:** Scapular protraction has been associated with several shoulder injuries. Due to the attachment of various posterior soft tissue structures to the scapula, many have hypothesized that posterior shoul-
der tightness is associated with scapular protraction.

**METHODS:** We tested scapular protraction and glenohumeral (GH) horizontal adduction, internal rotation, and external rotation range of motion (ROM) bilaterally for 20 professional baseball pitchers and 20 position players with no recent history of injury.

**RESULTS:** Multiple regression analysis showed a moderate-to-good negative relationship between GH horizontal adduction ROM and scapular protraction ($r^2 = .50, P = .001$). Poor relationships were shown between scapular protraction and both GH external and internal rotation ROM ($r^2 < .04, P > .23$). $t$ tests demonstrated that the dominant shoulder of both groups had significantly more scapular protraction compared to the nondominant side ($P < .004$). Furthermore, the dominant shoulders of the pitchers had significantly more scapular protraction compared to the position players ($P = .03$). There was no significant difference for scapular protraction of the nondominant shoulder between groups ($P = .15$).

**CONCLUSIONS:** Our moderate-to-good relationship suggests that posterior shoulder tightness may be considered a partial predictor for scapular protraction. The increased scapular protraction in the dominant arm of pitchers compared to position players may help partially explain the higher prevalence rate of shoulder injuries among pitchers. Clinicians may find it advantageous to address these characteristics when examining and treating such athletes.

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**SUBACROMIAL VERSUS INTERNAL IMPINGEMENT: INSIGHTS FROM 3-D IN-VIVO MOTION ANALYSIS**

Ludewig PM, Hybben NM, Peterson BW, Nyström CS, Pham TD, Phadke V, Brennan JP, LoPrade RF

**STUDY DESIGN:** Controlled laboratory experiment.

**OBJECTIVE:** To quantify the 3-D minimal distance to potential impinging structures during active elevation motions and distinguish kinematics of internal and subacromial impingement.

**BACKGROUND:** Shoulder impingement is thought to be the compression of rotator cuff soft tissues beneath the coracoacromial arch (subacromial) or with the glenoid-labral complex (internal) as the arm is raised overhead.

**METHODS:** Kinematic data were collected using electromagnetic motion tracking for 19 subjects, 8 symptomatic for shoulder impingement. Computed tomography scans were reconstructed into 3-D models of the shoulder (scapula, humerus, clavicle). Models were rotated based on kinematic data to calculate subacromial and glenoid minimal distances at rest and at 30°, 60°, 90°, and 120° of elevation during scapular plane abduction, flexion, and abduction. Three-way ANOVAs were calculated for the effects of motion and angle across groups. The symptomatic group was categorized based on clinical presentation and kinematic parameters into those believed to represent internal impingement versus subacromial or combined subacromial and internal impingement.

**RESULTS:** The supraspinatus insertion footprint on the humerus was significantly closer to the undersurface of the acromion at 60° versus 30° and 90° for abduction and scapular plane abduction. The linear distance between the glenoid and the infraspinatus insertion, as well as the posterior insertion point of the supraspinatus tendon, was significantly less for the symptomatic group versus the asymptomatic group at 90° and 120° of humerothoracic elevation (approximately 4-5 mm). Subgrouping the symptomatic subjects demonstrated angular kinematic distinctions between subgroups and greater reductions in glenoid distances in those most representing internal impingement.

**CONCLUSIONS:** The lateral edge of the greater tuberosity came closest to the undersurface of the acromion at 90°. The supraspinatus insertion was in closest proximity to the acromial undersurface at 60° of elevation, and closer to the glenoid at 120° of elevation and above. Proximity to the glenoid reflects internal rather than subacromial impingement. The symptomatic group appeared to present with more internal rather than subacromial impingement, which may be more frequent than clinically recognized.

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**KINEMATIC AND MUSCLE ACTIVATION CHANGES AFTER AN ISOMETRIC TASK TO FATIGUE SHOULDER MUSCLES**

**Borstad J, Szczes K, Navealgund A**

**STUDY DESIGN:** Controlled laboratory experiment.

**OBJECTIVE:** To determine the effect of acute shoulder muscle fatigue on scapula kinematics and shoulder muscle activation in healthy individuals.

**BACKGROUND:** Coordinated activation of shoulder muscles is required to control the scapulothoracic (ST) articulation during arm elevation. In particular, serratus anterior activity is considered vital to ST movement. Because scapular kinematic and muscle activity alterations have been identified in individuals with subacromial impingement syndrome (SIS), fatigue of serratus anterior may be a mechanism for these altered scapula motions, possibly through compensation by other ST muscles.

**METHODS:** Scapula kinematic and muscle electromyography (EMG) data were collected from 26 subjects before and after a task to fatigue serratus anterior. The fatigue task was a modified push-up plus held until subjects quit voluntarily. Percent decline in median power frequency (MPF) measured muscle fatigue and the Borg CR10 scale rated subjective fatigue. Scapula kinematics, muscle activation, and muscle coactivation pre-fatigue and post-fatigue were compared at 60°, 90°, and 120° of arm elevation with repeated measures ANOVA.

**RESULTS:** The fatigue task decreased MPF in all muscles. Borg score increased at post-task. Scapula posterior tilting decreased and internal rotation increased following the fatigue task. Only upper trapezius had higher activation post-task, while serratus anterior to lower trapezius coactivation was altered. Higher upper trapezius activation may be compensatory for fatigue of other ST muscles.

**CONCLUSION:** Shoulder muscle fatigue contributes to scapular kinematic and muscle activation alterations and is a plausible mechanism for SIS. Serratus anterior endurance training may prevent shoulder pathology.

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**RECOVERY OF SCAPULA KINEMATICS FOLLOWING AN ISOMETRIC FATIGUE TASK**

**Borstad J, Szczes K, Navealgund A**

**STUDY DESIGN:** Controlled laboratory experiment.

**OBJECTIVE:** Based on previous work demonstrating scapula kinematic alterations following an isometric fatigue task, this study aimed to determine if kinematics return to pre-fatigue levels following rest.

**BACKGROUND:** Scapula kinematic alterations have been reported in healthy individuals following acute shoulder muscle fatigue, suggesting fatigue as a mechanism for subacromial impingement syndrome (SIS) in individuals exposed to repetitive overhead activity. Understanding how periods of rest impact these fatigue-induced alterations may aid in SIS prevention and treatment.

**METHODS:** Ten male subjects had 3-D shoulder kinematic data collected during scapular plane arm elevation and lowering at 4 time points: prefatigue, immediately post-fatigue, and 3 and 6 minutes post-fatigue. The fatigue task was a modified isometric push-up plus held until subjects quit voluntarily. Muscle fatigue was determined by percent decline in median power frequency (MPF). Scapula orientation relative to the trunk was analyzed at 60°, 90°, and 120° of humerus elevation with a 2-factor (time by angle) repeated measures ANOVA.

**RESULTS:** MPF percent decline during the fatigue task indicated acute muscle fatigue. During both arm elevation and lowering there was increased scapula internal rotation at all 3 post-fatigue time points, increased scapula upward rotation at 6 minutes, and increased scapula anterior tilting at post-task.

**CONCLUSION:** Fatigue-induced scapula kinematic alterations did not recover after 6 minutes. Scapula internal rotation and anterior tilting increases due to fatigue may make overhead workers or athletes susceptible to SIS.
PHYSICAL EXAMINATION OF THE SCAPULA: A SYSTEMATIC REVIEW
Kohn JE

STUDY DESIGN: Systematic review.

OBJECTIVE: To assess accuracy and reliability of scapula physical examination tests.

BACKGROUND: Alterations in scapula position or dynamics contribute to shoulder pathology. Understanding the accuracy and precision of scapula physical examination tests is clinically helpful.

METHODS: A literature search using terms “scapula and physical exam” was conducted. Manuscripts selected included evaluations of scapula physical exam techniques in normal and symptomatic subjects. Review papers and studies employing devices that would not be clinically available were excluded. Twenty-two manuscripts were reviewed in detail to assess methodology, and accuracy and reliability of the physical examination tests. These tests included: static examinations of scapula position, dynamic evaluations of the scapula, and special tests such as the scapula assistance test (SAT) and the scapula retraction test (SRT).

RESULTS: Static measurements of scapula position had better agreement when the patient’s arms were at rest, compared to other positions. Static scapula position cannot distinguish between symptomatic and asymptomatic shoulders. Dynamic scapula examination has relatively poor agreement. Scapular dyskinesis cannot be used to identify a pathologic shoulder. The SRT and the SAT have fairly high agreement. The SRT significantly increases elevation strength, but does not affect pain. The SAT is effective at reducing pain in patients with painful shoulder elevation.

CONCLUSIONS: Measurement of scapula position with the arms at rest is reliable but not accurate at identifying the symptomatic shoulder. Dynamic measures to identify scapula dyskinesis are neither reliable nor accurate. The SRT will produce increased elevation strength, but may not correlate with pain. The SAT is effective in reducing elevation-related shoulder pain.

A CLINICAL TEST FOR SCAPULAR DYSKINESIS: RELIABILITY AND VALIDITY
McClure PW, Tate AR, Kareha S, Irwin D

STUDY DESIGN: Correlation design using ratings from multiple pairs of testers for reliability and comparison of tester visual ratings with instrumented 3-D motion testing.

OBJECTIVE: To determine the interrater reliability and validity of a visually based test for scapular dyskinesis.

BACKGROUND: Shoulder injuries are common, particularly in athletes involved in overhead sports, and scapular dyskinesis is believed to be aetiologic factor in these injuries.

METHODS: The sample was 142 athletes participating in sports requiring intense overhead use of the arm. Subjects were videotaped from a posterior view while performing 5 repetitions of bilateral, weighted shoulder flexion and frontal plane abduction. Videotapes from randomly chosen subjects were subsequently viewed and independently rated for the presence of scapular dyskinesis by 6 raters (3 pairs), with each pair rating 3 different subjects. Raters were trained to detect scapular dyskinesis using a self-instructional format with standardized operational definitions and video examples. Percent agreement and weighted kappa ($K_w$) coefficients were calculated to determine reliability. A subset of athletes ($n = 60$) judged as having either “normal” motion or “obvious dyskinesis” underwent 3-D electromagnetic kinematic testing while performing the same movements. The kinematic data from both groups were compared using a multivariate ANOVA with post hoc testing using the LSD procedure. The relationship between symptoms and scapular dyskinesis was evaluated by odds ratios.

RESULTS: Percent agreement was between 75% to 82% and $K_w$ ranged from 0.48 to 0.61. Significant differences in 3-D kinematics were found between the “normal” and “obvious dyskinesis” groups with the subjects with dyskinesis showing less upward rotation and clavicular elevation and greater clavicular protraction. The presence of shoulder symptoms was not significantly different between the “normal” and “obvious dyskinesis” subjects (OR, 0.79; 95% CI: 0.33-1.89).


IS SCAPULAR DYSKINESIS RELEVANT IN PATIENTS WITH IMPINGEMENT SYNDROME?
Michener LA, Seitz AI, McClure PW, Tate AR

STUDY DESIGN: Prospective cohort.

OBJECTIVE: To determine if the presence of scapular dyskinesis as measured by a clinical dyskinesis exam changes over the course of treatment in patients with subacromial impingement syndrome (SAIS), and if changes in dyskinesis are related to outcome.

BACKGROUND: Patients with SAIS have demonstrated scapular kinematic differences as compared to healthy individuals. The relevance of these scapular kinematic alterations to symptoms and outcomes has not been established using a clinical examination for scapular dyskinesis.

METHODS: Patients with SAIS ($n = 80$) participated. Scapular dyskinesis was evaluated using a standardized clinical exam method previously demonstrated to be reliable and valid. Scapular motion was observed for the presence of winging and dysrhythmia during 5 repetitions of arm elevation. Winging was defined as posterior displacement of the inferior angle or medial border of the scapula, and dysrhythmia was defined as a lack of normal scalapolumenal rhythm during raising/lowering of the arm. Dyskinesis was rated as normal/subtle (normal); obvious; obvious if winging or dysrhythmia was present or 3 of 5 repetitions. Dyskinesis was evaluated at initial evaluation (IE) and discharge (DC) after a standardized treatment consisting of 8-10 sessions provided over an average of 5 weeks. Treatment consisted of stretching and strengthening exercises, manual therapy, and a home exercise program. Outcomes were (1) average pain with rest, normal activities, and strenuous activities rated on a numeric 0-10 scale (0, no pain), (2) function as measured with the Disabilities of Arm Shoulder Hand (DASH) questionnaire on a 0-100 scale (0, no disability), and a 13-point global rating of change (GROC) scale. Outcome was dichotomized as successful ($\geq 50\%$ change in DASH score ([DASH IE - DASH DC]/DASH IE $\times 100$) and “moderately better” on the GROC) and not successful (less than $50\%$ change on the DASH and less than “moderately better” on the GROC).

RESULTS: Treatment resulted in significant improvement in all outcomes, regardless of scapular dyskinesis (pain: $F = 35.3, P < .001$; GROC: $F = 11.9, P < .001$; DASH: $F = 41.0, P < .001$). Subjects were divided into 2 groups based on their intake exam: obvious dyskinesis $n = 22$, and normal $n = 58$. Groups were compared for outcomes using chi-square or t test or a repeated-measures mixed-model ANOVA/ANCOVA ($P = .05$). No differences were found in any outcome measure or dichotomized outcome between dyskinesis groups. At DC, there were no $5$ obvious dyskinesis and $n = 73$ normal/subtle dyskinesis. There was a significant improvement in scapular dyskinesis at DC ($\chi^2 = 6.9, P = .009$). Subjects with obvious dyskinesis at IE were also classified by their change in scapular dyskinesis, “positive” group ($n = 4$) with obvious dyskinesis at both IE and DC, and “negative” group ($n = 18$) with obvious dyskinesis at IE and normal/subtle at DC. Subjects in the “positive” group had lower GROC versus those in the “negative” group ($t = 4.9, P = .04$). There were no other significant differences in outcomes between groups.

CONCLUSIONS: In patients with SAIS, the presence of scapular dyskinesis did not differentiate outcome of pain or function. The presence of obvious scapular dyskinesis does improve with treatment to subtle/normal.
However, for patients with obvious dyskinesis, a change to subtle/normal dyskinesis resulted in improvement in GROC outcome only when compared to those with obvious dyskinesis that did not improve at DC. Pain and function outcomes do not differ between patients with and without the presence of scapular dyskinesis. Scapular dyskinesis does improve with treatment, however this change has only limited relationship to outcomes.

**KINEMATIC AND NEUROMUSCULAR ACTIONS DURING THE SCAPULAR RETRACTION TEST (SRT)**

**STUDY DESIGN:** Controlled laboratory study.

**OBJECTIVE:** To determine the extent to which scapular kinematics and EMG signal amplitude are altered while performing the SRT.

**BACKGROUND:** The SRT is a clinical assessment test hypothesized to alter scapular position to help identify the contribution of scapular dysfunction to a shoulder injury.

**METHODS:** Nine injured (age, 25 ± 8 years) and 7 healthy subjects (age, 34 ± 14 years) participated. Subjects were instrumented with electromagnetic sensors secured to their sternum, humerus, and acromion. Surface electrodes were placed over the serratus anterior, middle deltoid, upper and lower trapezius, with indwelling electrodes in the supraspinatus. Subjects placed their arm in an empty can testing position with resistance applied below the elbow with the scapula stabilized in a retracted position and unstabilized. EMG and scapular kinematics were calculated for each trial. Data were analyzed with a repeated measure ANOVA with 1 within factor and 1 between group factor.

**RESULTS:** The SRT was shown to increase retraction of the scapula by 5° ± 6° from a protracted position of 11° ± 21° (unstabilized) (P = .005). Posterior tilt was also shown to increase from 4° ± 8° (unstabilized) to 16° ± 8° (stabilized) (P = .0002); internal rotation was reduced from 22° ± 16° (unstabilized) to 13° ± 14° (stabilized) (P = .002) and elevation was further reduced 15° ± 17° (stabilized) from a slightly depressed position of 2° ± 25° (P = .006). EMG data were not shown to differ during stabilization.

**CONCLUSIONS:** Observed kinematic changes place the glenohumeral joint in a biomechanically favorable position for function; however, this acute change does not appear to create immediate sensorimotor changes.

**THE EFFECT OF THE SCAPULAR ASSISTANCE TEST ON SCAPULAR KINEMATICS IN THE CLINICAL EXAM**

**Kibler WB, Uhl TL, Cunningham TJ**

**STUDY DESIGN:** Controlled laboratory study.

**OBJECTIVE:** To determine if the scapular assistance test (SAT) changes scapular kinematics and muscular activation.

**BACKGROUND:** Scapular dyskinesis is associated with a variety of shoulder pathologies and is thought to be one cause of symptoms. We theorize that the SAT alters scapular motion and thereby alters clinical signs.

**METHODS:** Nine injured (age, 25 ± 8 years) and 7 healthy subjects (age, 34 ± 14 years) participated. Subjects were instrumented with electromagnetic sensors secured to their sternum, humerus, and acromion. Surface electrodes were placed over the serratus anterior, middle deltoid, upper and lower trapezius, with indwelling electrodes in the supraspinatus. Subjects were instructed to elevate their arm 3 times in the plane of the scapula (unassisted) and repeat with their scapular motion assisted. Pain experienced during each trial was recorded on a 0- to 100-mm scale. EMG signal and scapular kinematics were calculated at 30°, 60°, 90°, and 120° of arm elevation. Data were analyzed with a repeated-measures ANOVA (within-factors, angle and test; between-factor, healthy and injured).

**RESULTS:** The SAT significantly altered posterior tilt and elevation in both injured and healthy subjects. Posterior tilt increased an average of 7° ± 1° (P < .001) and scapular elevation was reduced 11° ± 1° (P = .04) across all angles. For the injured population, the SAT resulted in a 3% reduction of EMG signal in the serratus anterior at 30° (P = .03) and 60° (P = .008). An 8-mm (56%) reduction in pain was observed (P = .017).

**CONCLUSIONS:** The SAT does change several aspects of scapular kinematics in conjunction with altering subject symptoms. The SAT appears to reverse previously reported pathological scapular kinematic alterations.

**CORRELATION OF OBSERVED SCAPULAR MOTIONS WITH BIOMECHANICALLY DETERMINED KINEMATICS**

**Kibler WB, Uhl TL, Geecwich E, Tripp B**

**STUDY DESIGN:** Controlled laboratory study.

**OBJECTIVE:** To (1) assess the interrater reliability and validity of 2 clinical assessment methods of categorizing scapular dyskinesis, and (2) quantify the frequency of asymmetry of bilateral scapular motion in injured and noninjured shoulders using 3-D kinematic analysis.

**METHODS:** 56 subjects were evaluated, 35 with shoulder injury and 21 with no symptoms. Two blinded evaluators categorized the scapular motion of all subjects to determine interrater reliability using 2 observational methods (“yes/no” and “4-type”) to evaluate scapular dyskinesis. Subjects were instrumented with electromagnetic receivers to assess bilateral 3-D scapular kinematics to determine the presence of dyskinesis and establish criterion validity of the 2 methods.

**RESULTS:** The interrater percent agreement and the extent of this agreement as measured by kappa statistic revealed that the yes/no method produced higher interrater percent agreement (79%, k = .40) than the (4-type) method (61%, k = .44). The Yes/No method had higher sensitivity (76%) and positive predictive value (74%) when compared to the 3-D criterion. A chi-square analysis found significantly more multiplanar asymmetries in symptomatic (54%) subjects in flexion compared to asymptomatic subjects (14%) (P = .002).

**CONCLUSIONS:** The ‘yes/no’ method allows multiplanar asymmetries to be considered in clinical assessment. It therefore renders a good screening tool for the presence of scapular dyskinesis. Kinematic analysis reveals that asymmetries are common in symptomatic and asymptomatic populations. Testing in flexion demonstrated the higher frequency of multiplanar scapular asymmetries in the symptomatic group.

**CLINICAL RELEVANCE:** Identification of scapular dyskinesis is a key component of the shoulder examination. Clinicians’ ability to establish the presence or absence of scapular dyskinesis by observation is enhanced using a simple “yes/no” method especially in shoulder forward flexion. Although scapular asymmetries appear prevalent, in the presence of shoulder symptoms it should be considered a potential factor contributing to the dysfunction. Note: This abstract is based on the following published paper: Uhl TL, Kibler WB, Geecwich B, Tripp BL. Correlation of observed scapular motions with biomechanically determined kinematics. *Arthroscopy* 2009; In press.

**Intervention**

**RESTORATION OF SCAPULAR MUSCLE BALANCE AND TIMING PATTERN: WHICH EXERCISES TO PRESCRIBE?**

**Cools AM, De Mey K, Witvrouw EE**

**STUDY DESIGN:** Controlled laboratory study.

**OBJECTIVE:** The hypothesis of this study was that out of a number of commonly used trapezius strengthening exercises, a selection can be performed for muscle balance rehabilitation, based on a low UT/LT, UT/MT (study 1), and early LT and MT activation (study 2).

**BACKGROUND:** Strengthening exercises for the scapular muscles are used in the treatment of scapulothoracic dysfunction, related to shoulder pathology. In view of the intermuscular and intramuscular imbalances and relative delays in activation of lower (LT) and middle (MT) trapezius, often established in these patients, exercises promoting early and increased LT and MT activation with minimal activity in the upper trapezius (UT) are recommended.

**METHODS:** Electromyographic signal of the 3 sections of the trapezius was determined in 16 male and 16 female patients with chronic shoulder pain.
measured in 45 (study 1, balance ratio) and 30 (study 2, trapezius muscle timing) healthy subjects performing 12 (study 1) or 4 (study 2) commonly described scapular exercises, using surface EMG. Normalized muscle activity, muscle balance ratios, and relative muscle reaction times with respect to glenohumeral muscle activation were measured.

RESULTS: For each intramuscular trapezius ratio (UT/LT, UT/MT), 4 exercises were selected for restoration of muscle balance. The exercises "side-lying external rotation," "side-lying forward flexion," "prone horizontal abduction with external rotation," and "prone extension" were found to be the most appropriate for intramuscular trapezius muscle balance rehabilitation. With the exception of side-lying forward flexion, all exercises also showed a muscle sequence activation in which LT and MT were activated prior to UT or glenohumeral muscles.


**COMPARISON OF UPPER TRAPEZIUS/SERRATUS ANTERIOR RATIOS DURING POST-SURGICAL ACTIVE ASSISTIVE RANGE OF MOTION EXERCISES**

**Objective:** To determine if the upper trapezius to serratus anterior (UT/SA) ratio differs between active assistive exercises in healthy and post-SLAP repaired participants.

**Background:** During rehabilitation, patients are advised to regain shoulder elevation using assistive devices. During this period of rehabilitation several techniques are used to minimize substitution patterns. It is unclear if one technique reduces the UT/SA ratio the most.

**Methods:** Twenty participants, 10 healthy (age, 28 ± 6 years) and 10 post-SLAP repair (age, 28 ± 9 years), 4 to 6 weeks following surgery. Data from 9 post-SLAP repair participants were analyzed due to poor EMG signal. Five active assistive exercises: (rope and pulley, wall walk, stick-assisted elevation, UE ranger-assisted elevation, UE ranger-active elevation) and active forward elevation were performed in random order at 20°/s without increasing pain. Surface electromyographic (EMG) electrodes were applied to the UT and SA. EMG root mean squared (RMS) amplitudes were normalized to a submaximal reference voluntary contraction (%RVC). The ratio of UT/SA activity was used in a mixed model ANOVA with group and exercises as factors, with significance set at P<.05.

**Results:** The healthy group (1.4% ± 1.1%) produced a larger ratio than the post-SLAP group (0.99% ± 0.71%). No significant interaction was revealed; however, the rope and pulley exercise produced the lowest ratio for the post-SLAP cohort (0.76% ± 0.78%).

**Conclusions:** These results reinforce the need to utilize patients in evaluating exercise programs. No active assistive exercises significantly reduced the UT or facilitated SA activity in relation to active elevation. EMG amplitudes and ratios should both be considered when prescribing rehabilitation exercises so as to not create substitution patterns.

**SCAPULAR REHABILITATION EXERCISES: WHAT’S THE INFLUENCE OF THE KINETIC CHAIN?**

**Objective:** To examine the influence of lower limb position and movement during closed (study 1) and open (study 2) chain exercises in a scapular rehabilitation program.

**Background:** Strengthening exercises for the scapular muscles are used in the treatment of scapulothoracic dysfunction, related to shoulder pathology. In view of the recent tendencies with respect to functional kinetic chain exercises, further study is needed.

**Methods:** Electromyographic signal of the scapular muscles was measured in 32 (study 1 – closed chain exercises) and 30 (study 2 – open chain exercises) healthy subjects performed 6 variations of the push-up exercise (study 1) or 16 variations of the vertical rowing open chain exercise (study 2), using surface EMG. Normalized muscle activity and muscle balance ratios were measured.

**Results:** During the push-up exercises, extension of the ipsilateral limb increases serratus anterior activity, and thus optimizes upper trapezius/serratus anterior ratio, extension of the contralateral limb improves upper trapezius/lower trapezius ratio. In general upper trapezius signal amplitude is lower in “low load” push-up exercises, and the use of an unstable surface does not influence muscle activity or intermuscular and intramuscular ratio. During open chain vertical row, unilateral stance on the contralateral limb increases lower trapezius activity, while sitting and bilateral stance positions are not favourable for lower trapezius activity or intramuscular muscle balance in the trapezius muscle.

**Conclusion:** The scapular muscle recruitment during rehabilitation exercises might be influenced by lower extremity position or movement, thus suggesting kinetic chain influences on shoulder girdle exercises. Note: This abstract is based on the following published paper. Maenhout AG, Pizzi L, Van Praet K, Cools AM: Electromyographic analysis of knee push-up plus variations: what is the influence of the kinetic chain on scapular muscle activity? *Br J Sports Med.* 2009; In press.

**SCAPULAR MUSCLE DETACHMENT: CLINICAL PRESENTATION AND RESULTS OF TREATMENT**

**Objective:** To report a new surgical technique and associated post-surgical outcomes of a cohort of patients that have been identified with a syndrome of scapular dysfunction associated with severe pain along the medial border of the scapula following traumatic injury to the shoulder with no relief by common therapeutic methods.

**Background:** This study describes the clinical presentation, treatment, and outcomes in a cohort of patients found to have detachment of the medial scapular stabilizing muscles.

**Methods:** 93 patients (age, 35.5 ± 11 years) were included, with clinical follow up ranging from 6 months to 7 years. Inclusion criteria included history of trauma, tensile load or previous surgery to the area along the medial scapular border, localized pain at the superior medial and/or medial scapular border, scapular dyskinesia with arm motion, decreased rotator cuff strength, increased pain and decreased function with arm forward elevation, and relief of pain and arm dysfunction by manual scapular stabilization. The localized pain was a prominent common problem, and averaged 8.2 (± 1.1) on a visual analogue scale (VAS). All patients failed multiple treatment regimens. Magnetic resonance imaging and other imaging were negative in 91 patients. Average time from initial injury to definitive treatment was 4 years (range, 6 months to 17 years).

**Results:** Operative treatment was accomplished by identification and mobilization of damaged/torn muscle and reattachment to the body and the spine of the scapula through trans-scapular drill holes. Lower trapezius and rhomboid muscles were either detached or loosely attached through scar in all patients and serratus anterior detachment was present in 9 patients. Significant relief of preoperative pain was noted in all patients by 6 weeks – VAS score was 1.7 (±1.4), only 2 patients had a VAS score greater than 4.0. Increased shoulder function, measured by improvement in arm forward flexion was noted by 12 weeks in 94% of patients.

**Conclusion:** Medial scapular muscle detachment is a syndrome that can be characterized by a consistent history and physical findings. Operative reattachment of detached scapular muscles provided predictable pain relief and resulted in improved function in the large majority of patients.