PASIG MONTHLY CITATION BLAST: No.24 **September 2007**

Dear PASIG members:

As everyone is catching up this fall following vacations and other summer activities, I hope you will make a note to yourself to vote in the upcoming PASIG and Orthopaedic Section elections. As you do so, drop an e-mail note to one of our PASIG Board members. We'd like to know what you're up to.

And, don't forget, the PASIG sponsors an annual student research scholarship. This award is to recognize students, who have had an abstract accepted to CSM, for their contribution to performing arts research. For more information on the research award please check our webpage (www.orthopt.org/sig_pa.php). The deadline for application is November 15, 2006.

If any of you are seeking a performing arts position, PASIG member Jill Tomasello has submitted this.

> PT-owned practice is looking for **Performing Arts PT** to join our team to continue established relationship with local dance and ballet schools. Large practice with 2 gyms and 20 private treatment rooms. Great opportunity to expand niche practice within well established orthopedic facility. Competitive salary and benefits.
> Fax resume to: 203-352-1915
> or e-mail: Jill.Tomasello@yahoo.com
> Advanced Physical Therapy Center
> 999 Summer Street, Stamford, CT 06905

This summer and fall, many of us have been busy conducting pre-season screening of both professional and student dancers. If any of you are interested in learning more by getting involved, contact me and I can direct you to one of these groups. With more and more dance screenings occurring throughout the country, to all of you out there, I

continue to pose this question: How can we move forward in this area with musicians and orchestras?

This month's Citation BLAST continues our special topic series: "*Scapulothoracic Joint Dysfunction and Control*", contributed by one of our student members, Valerie Williams (Slippery Rock University). The format is an annotated bibliography of articles on the selected topic from 1996 – 2006. As always, each month's citations will be added to EndNote libraries available on the PASIG webpage for our members to access and download. (Information about EndNote referencing software can be found at http://www.endnote. com, including a 30-day free trial). If you'd like to suggest a topic or create one, please let me know.

Please write to me with your comments and suggestions. If you're seeking a research mentor, looking for a sounding board about a research idea, want some editorial suggestions on a manuscript, let me know and I'll try to connect you with the right researcher. Entry contributions to these Citation Blasts or other PA research ideas are always welcome.

Thanks,
Shaw

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SCAPULOTHORACIC JOINT DYSFUNCTION AND CONTROL

The scapulothoracic joint plays an important role in movement of the upper extremity. The scapula must move along the ribcage to maintain proper alignment of the glenohumeral joint. Poor scapular positioning can lead to shoulder dysfunction, as normal scapulo-humeral rhythm is needed to keep the humerus centered in the glenoid cavity. The scapulothoracic joint is unique in that its integrity is maintained solely by musculature and has no ligamentus support. The scapula itself serves as an origin for the rotator cuff muscles, which stabilize the humerus on the glenoid. Poor positioning of the scapulo-thoracic joint alters the length tension relationship of these muscles and negatively effects shoulder stabilization.

Injuries to the shoulder joint have been reported in dancers and gymnasts, although they do not make up the majority of injuries in these populations. However, understanding scapulothoracic control and stabilization of the shoulder joint is important in the treatment of dancers and gymnasts when shoulder injuries do occur. Dancers and gymnasts have been reported to have greater ranges of motion and laxity at all joints, including the shoulder. Joint laxity can, but does not always, affect the stability of the shoulder. Instability of the shoulder is related to a variety of shoulder problems, although not all patients with unstable shoulders are symptomatic. For those patients who do have shoulder pathologies, strengthening the muscles that stabilize the scapulothoracic and glenohumeral joints can improve shoulder function. I hope you will find the following

annotated bibliography useful for understanding the function of the muscles that stabilize the shoulder and exercises that can be used to strengthen them.

Valerie Williams, SPT

Background

Gannon LM, Bird HA (1999). The quantification of joint laxity in dancers and gymnasts. *J Sports Sci* 17: 743-750.

The aim of this study was to determine the range of movement in gymnastic and dance populations. Sixty-five participants (41 females, 24 males; mean age 21.4 years) were assessed. The sample included dancers and gymnasts ranging from novice and club standard to international and professional status. Non-specialized physical education students acted as controls. Range of movement was measured at the shoulders, hips, lumbar spine and ankles using a Loebl hydrogoniometer, and inherent joint laxity was assessed using Beighton and coworkers' adaptation of the Carter and Wilkinson 9-point scale. The right and left sides of the body were assessed and measures of active and passive motion were recorded. A graded increase in laxity was observed from controls, through novice gymnasts, to dancers and finally international gymnasts. The greater laxity of females than males was also confirmed. Dancers and gymnasts had a greater passive range of movement in all joints, which was partly inherited and partly acquired. There was a large difference between their active and passive ranges, which appeared to render the joints unstable.

Sohl P, Bowling A (1990). Injuries to dancers. Prevalence, treatment, and prevention. *Sports Med* 9: 317-322.

Studies from the USA and UK indicate that the back, neck and shoulder and the lower limb (particularly the hip, knee, ankle and foot) are the most frequent sites of injury among dancers. Most injuries are soft tissue injuries. Most dancers experience injuries at some time and about half have chronic injuries. Shoulder injuries appear to be caused by frequent or unaccustomed lifting, and are treated by rest and oral anti-inflammatory medication. Back injuries include sprains, prolapsed or herniated intervertebral discs, and spondylolytic stress fractures. Several risk factors, especially training error, have been identified for overuse injuries. Hip injuries include degenerative changes and osteoarthritis, stress fractures, bursitis and damage to the sciatic nerve. The most common foot injury is an anterior lateral ligament sprain, which may lead to permanent instability in the ankle. More soundly based research into the prevalence, diagnosis and treatment of injuries is needed.

Warner JJP, Micheli LJ, Arslanian LE, Kennedy J, Kennedy R (1990). Patterns of flexibility, laxity, and strength in normal shoulders and shoulders with instability and impingement. *Am J Sports Med* 18: 366-375.

Imbalance of the internal and external rotator musculature of the shoulder, excess capsular laxity, and loss of capsular flexibility, have all been implicated as etiologic factors in glenohumeral instability and impingement syndrome; however, these assertions are based largely on qualitative clinical observations. In order to quantitatively define the requirements of adequate protective synergy of the internal and external rotator musculature, as well as the primary capsulolabral restraints, we prospectively evaluated 53 subjects: 15 asymptomatic volunteers, 28 patients with glenohumeral instability, and 10 patients with impingement syndrome. Range of motion was evaluated by goniometric technique in all patients with glenohumeral instability and impingement. Laxity assessment was performed and anterior, posterior, and inferior humeral head translation was graded on a scale of 0 to 3+. Isokinetic strength assessment was performed in a modified abducted position using the Biodex Clinical Data Station with test speeds of 90 and 180 deg/sec. Internal and external rotator ratios and

internal and external rotator strength deficits were calculated for both peak torque and total work. Patients with impingement demonstrated marked limitation of shoulder motion and minimal laxity on drawer testing. Both anterior and multidirectional instability patients had excessive external rotation as well as increased capsular laxity in all directions. Sixty-eight percent of the patients with instability had significant impingement signs in addition to apprehension and capsular laxity. Isokinetic testing of asymptomatic subjects demonstrated 30% greater internal rotator strength in the dominant shoulder. Comparison of all three experimental groups demonstrated a significant difference between internal and external rotator ratios for both peak torque and total work. Conclusions are that there appears to be a dominance tendency with regard to internal rotator strength in asymptomatic individuals. Impingement syndrome and anterior instability have significant differences in both strength patterns of the rotator muscles and flexibility and laxity of the shoulder. Isokinetic testing potentially may be helpful in diagnostically differentiating between these two groups in cases where there is clinical overlap of signs and symptoms.

Bahk M, Keyurapan E, Tasaki A, Sauers EL, McFarland EG (2007). Laxity testing of the shoulder: a review. *Am J Sports Med* 35: 131-144.

Laxity testing is an important part of the examination of any joint. In the shoulder, it presents unique challenges because of the complexity of the interactions of the glenohumeral and scapulothoracic joints. Many practitioners believe that laxity testing of the shoulder is difficult, and they are unclear about its role in evaluation of patients. The objectives of the various laxity and instability tests differ, but the clinical signs of such tests can provide helpful information about joint stability. This article summarizes the principles of shoulder laxity testing, reviews techniques for measuring shoulder laxity, and evaluates the clinical usefulness of the shoulder laxity tests. Shoulder laxity evaluation can be a valuable element of the shoulder examination in patients with shoulder pain and instability.

Scapulothoracic and glenohumeral motion and muscle activity

Illyes A, Kiss RM (2006). Kinematic and muscle characteristics of multidirectional shoulder joint instability during elevation. *Knee Surg, Sports Traumatology, Arthrosc* 14: 673-685.

Alterations of shoulder motion have been suggested to be associated with shoulder disorders. The objective of this study was to perform a 3D motion analysis (kinematic and electromyographical) of skeletal elements and muscles of shoulder joint in patients with multidirectional instability. Fifteen patients with multidirectional instability and 15 normal controls were investigated during continuous elevation in the scapular plane. The spatial coordinates of 16 anatomical points of the shoulder to determine kinematical parameters were quantified by an ultrasound-based motion analyzer. The activities of 12 muscles were measured by surface electromyography. Kinematic characteristics of motion were identified by scapulothoracic, glenohumeral, and humeral elevation angles; range of angles; scapulothoracic and glenohumeral rhythm; scapulothoracis, glenohumeral, and scapuloglenoid ratios; and the relative displacement between the rotation centers of the humerus and the scapula. The electromyographical characteristics of motion were modeled by the on–off pattern of muscle activity. Significant alterations in kinematical parameters were observed between patients and asymptomatic volunteers. The anterior, posterior, and inferior dislocations of shoulders with multidirectional instability could be properly modeled by the relative displacement between the rotation centers of the scapula and humerus. The shorter activity by m. pectoralis maior and all three parts of m. deltoideus and longer activity by m. supraspinatus, m. biceps brachii, and m. infraspinatus assure the centralization of the glenuhumeral head of a shoulder with multidirectional instability.

Ebaugh DD, McClure PW, Katduna AR (2005). Three-dimensional scapulothoracic motion during active and passive arm elevation. *Clin Biomechanics* 20:700-709.

Background. Scapulothoracic muscle activity is believed to be important for normal scapulothoracic motion. In particular, the trapezius and serratus anterior muscles are believed to play an important role in the production and control of scapulothoracic motion. The aim of this study was to determine the effects of different levels of muscle activity (active versus passive arm elevation) on three-dimensional scapulothoracic motion. Methods. Twenty subjects without a history of shoulder pathology participated in this study. Three-dimensional scapulothoracic motion was determined from electromagnetic sensors attached to the scapula, thorax and humerus during active and passive arm elevation. Muscle activity was recorded from surface electrodes over the upper and lower trapezius, serratus anterior, anterior and posterior deltoid, and infraspinatus muscles. Differences in scapulothoracic motion were calculated between active and passive arm elevation conditions. Findings. Scapular motion was observed during the trials of passive arm elevation; however, there was more upward rotation of the scapula, external rotation of the scapula, clavicular retraction, and clavicular elevation under the condition of active arm elevation. This was most pronounced for scapular upward rotation through the mid-range (90–120°) of arm elevation. Interpretation. The upper and lower trapezius and serratus anterior muscles have an important role in producing upward rotation of the scapula especially throughout the mid-range of arm elevation. Additionally, it appears that capsuloligamentous and passive muscle tension contribute to scapulothoracic motion during arm elevation. Assessment of the upper and lower trapezius and serratus anterior muscles and upward rotation of the scapula should be part of any shoulder examination.

Ebaugh DD, McClure PW, Katduna AR (2006). Effects of shoulder muscle fatigue caused by repetitive overhead activities on scapulothoracic and glenohumeral kinematics. *J Electromyography Kinesiology* 16: 224-235.

The purpose of this study was to determine the effects of shoulder muscle fatigue on three dimensional scapulothoracic and glenohumeral kinematics. Twenty healthy subjects participated in this study. Three-dimensional scapulothoracic and glenohumeral kinematics were determined from electromagnetic sensors attached to the scapula, humerus, and thorax. Surface electromyographic (EMG) data were collected from the upper and lower trapezius, serratus anterior, anterior and posterior deltoid, and infraspinatus muscles. Median power frequency (MPF) values were derived from the raw EMG data and were used to indicate the degree of local muscle fatigue. Kinematic and EMG measures were collected prior to and immediately following the performance of a shoulder elevation fatigue protocol. Following the performance of the fatigue protocol subjects demonstrated more upward and external rotation of the scapula, more clavicular retraction, and less humeral external rotation during arm elevation. All muscles with the exception of the lower trapezius showed EMG signs of fatigue, the most notable being the infraspinatus and deltoid muscles. In general, greater scapulothoracic motion and less glenohumeral motion was observed following muscle fatigue. Further studies are needed to determine what effects these changes have on the soft tissues and mechanics of the shoulder complex.

Ogston JB, Ludewig PM (2007). Differences in 3-dimensional shoulder kinematics between persons with multidirectional instability and asymptomatic controls. *Am J Sports Med* 35: 1361-1370.

Background: Evidence that persons with multidirectional instability (MDI) of the shoulder have abnormal shoulder kinematics is limited. A kinematic description of scapulothoracic and glenohumeral motion can assist both conservative and surgical rehabilitative programs. Hypothesis: Persons with MDI of the shoulder demonstrate increased anterior and inferior glenohumeral translation and decreased scapular upward rotation and increased scapular internal rotation compared with age-matched and gender-matched asymptomatic controls. Study Design: Controlled laboratory study. Methods: Sixty-two subjects were recruited from an outpatient orthopaedic clinic. Subjects with MDI were matched according to age, gender, and hand dominance to asymptomatic controls. An electromagnetic motion capture system

evaluated the 3-dimensional position of the trunk, scapula, and humerus during frontal and scapular plane elevation. A repeated measures analysis of variance evaluated joint positions and glenohumeral translations during 4 phases of elevation (0°-30°, 31°-60°, 61°-90°, and 91°-120°). Results: When averaged across the 4 phases of elevation, persons with MDI demonstrated a significant decrease in scapular upward rotation in scapular plane abduction (8°, P = .006) and abduction (5.8°, P = .016) and increased internal rotation during scapular plane abduction (12.2°, P = .03). Alterations in glenohumeral translations in the MDI group did not reach statistical significance (P = .54-.71). Conclusion: Abnormal scapular kinematics are seen in the MDI shoulder, highlighting the importance of incorporating scapular positioning and stability exercises during rehabilitation. Additional study is warranted concerning the efficacy of various rehabilitation programs, and also both surgical and nonsurgical interventions in this population.

Von Eisenhart-Rothe R, Matsen SA, Eckstein F, Vogl T, Graichen H (2005). Pathomechanics in atraumatic shoulder instability: scapular positioning correlates with humeral head centering. *Clin Orthop Rel Res* 433: 82-89.

The objective was to analyze three-dimensional scapular positioning and glenohumeral centering of normal and atraumatic unstable shoulders. We hypothesized that changes of humeral head position correlate with alterations of scapular positioning. The shoulders of 28 healthy volunteers and 14 patients with atraumatic instability were examined in various arm positions using open magnetic resonance imaging. After segmentation and three-dimensional reconstruction, three-dimensional analyses of scapular positioning and humeral head position relative to the glenoid were done. The coefficient of correlation (r) between both parameters was determined using the correlation z test. The glenohumeral to scapulothoracic ratio in the scapular plane was increased in nine of 14 patients and decreased in three patients, whereas the scapular internal rotation in the transverse plane was increased in all unstable shoulders. The unstable shoulders also had malcentering (greater than two times the standard deviation in the healthy volunteers) of the humeral head in the direction of instability during various arm positions. In healthy and unstable shoulders, the correlation between scapular position and glenohumeral positioning was high during passive elevation (r = 0.60-0.87). The high correlation suggests that scapular positioning is relevant for humeral head decentering. Therefore, physiotherapeutic strategy should consider the malpositioning of the scapula and be adapted to the direction of instability.

Turkel SJ, Panio MW, Marshall JL, Girgis FG (1981). Stabilizing mechanisms preventing anterior dislocation of the glenohumeral joint. *J Bone Joint Surg* 63: 1208-1217.

We investigated the stabilizing mechanism of the glenohumeral joint that prevents anterior dislocation by anatomical dissections of the subscapularis, the shoulder capsule, and the superior, middle, and inferior glenohumeral ligaments in thirty-six shoulders of embalmed cadavera. We also performed roentgenographic studies of ten unembalmed cadaver shoulders in which radiopaque markers were used to demonstrate the position, tightness, and laxity of the subscapularis muscle and of the middle and inferior glenohumeral ligaments during external rotation of the shoulder at zero, 45, and 90 degrees of abduction. The subscapularis muscle and the three glenohumeral ligaments were cut in different sequences to determine their relative contributions to stability (limitation of external rotation). The conclusions from these experiments were that at zero degrees of abduction, the subscapularis muscle stabilizes the joint to a large extent; at 45 degrees of abduction, the subscapularis, middle glenohumeral ligament, and anterosuperior fibers of the inferior glenohumeral ligament provide the stability; and as the shoulder approaches 90 degrees of abduction, the inferior glenohumeral ligament prevents dislocation during external rotation.

Cain PR, Mutschler TA, Fu FA, Lee SK (1987). Anterior stability of the glenohumeral joint. A dynamic model. *Am J Sports Med* 15: 144-148.

This study defines the interaction of the rotator cuff musculature and the glenohumeral ligaments in providing anterior stability to the glenohumeral joint. Eight cadaveric shoulders were studied using a testing frame that individually simulated the forces of the subscapularis, the supraspinatus, and the infraspinatus/teres minor musculature. The application of these forces abducted the humerus to approximately 90 degrees. The cocking phase of throwing was then simulated through the use of an Instron. With random variation of the rotator cuff forces, we investigated the effects that each force had on the rotation of the humerus and the strain of the inferior glenohumeral ligament. Our results demonstrate that the infraspinatus /teres minor muscle group was the most effective in controlling external rotation of the humerus and in reducing ligamentous strain. These observations are pertinent in the treatment of anterior instability syndromes of the shoulder.

Rodosky MW, Harner CD, Fu FH (1994). The role of the long head of the biceps muscle and superior glenoid labrum in anterior stability of the shoulder. *Am J Sports Med* 21: 121-130.

The authors conducted a study to determine if the long head of the biceps muscle and its attachment at the superior glenoid labrum play a role in stability of the shoulder in an overhead position. Their study used a dynamic cadaveric shoulder model that simulated the forces of the rotator cuff and long head of biceps muscles as the glenohumeral joint was abducted and externally rotated position. The biceps muscle also helps to diminish the stress placed on the inferior glenohumeral ligament. Detachment of the superior glenoid labrum is detrimental to anterior shoulder stability as it decreases the shoulder's resistance to torsion and places a greater magnitude of strain on the inferior glenohumeral ligament.

Therapeutic exercise interventions

Blackburn TA, McLeod WD, White B, Wofford L (1990). EMG analysis of posterior rotator cuff exercises. *Athletic Training* 25: 42-45.

A clear understanding of muscle activity is necessary for the rehabilitation of the posterior rotator cuff muscles. Electromyographic (EMG) analyses of the supraspinatus, infraspinatus, and teres minor muscles were done to determine optimum exercises for this muscle group. Twenty-eight subjects were studied using fine-wire intra-muscular electrodes in each of the three muscles. A series of tests compared many of the standard exercise positions with several more novel concepts. The EMG activity produced in the supraspinatus was maximized when the subject horizontally abducted the externally rotated humerus while prone. The infraspinatus and teres minor EMG activity were maximized in the prone position with an external rotation movement with the glenohumeral joint at 90 degrees and the elbow at 90 degrees.

Malanga GA, Jenp YN, Growney ES, An KN (1996). EMG analysis of shoulder positioning in testing and strengthening the supraspinatus. *Med Sci Sports Exerc*. 28: 661-664.

We examined the electromyographic (EMG) activity of the supraspinatus and other rotator cuff muscles, the three portions of the deltoid muscle, and the pectoralis major muscle in two previously suggested positions for isolating the supraspinatus. The position suggested by Jobe and colleagues is with the elbow extended, the shoulder in full internal rotation, and the arm in the scapular plane. Blackburn and colleagues recommended the prone position, with the elbow extended and the arm abducted to 100 degrees and externally rotated. Fine-wire EMG activity was obtained from the rotator cuff muscles and surface EMG from the other muscles in 17 subjects tested in these two positions. Both positions resulted in significant activity of the supraspinatus, but the difference between these two positions was not statistically significant. The Jobe position produced greater activation of the anterior deltoid and pectoralis major, whereas the Blackburn position caused greater activation of the posterior deltoid. Both positions produced significant activation of the middle deltoid. We

conclude that either position can be used to strengthen the supraspinatus; however, neither position selectively isolates the supraspinatus during manual muscle testing.

Reinold MM, Wilk KE, Fleisig GS, Zheng N, Barrentine SW, Chmielewski T, Cody RC, Jameson GG, Andrews JR (2004). Electromyographic analysis of the rotator cuff and deltoid musculature during common shoulder external rotation exercises. *J Orthop Sports Phys Ther* 34: 385-394.

STUDY DESIGN: Prospective single-group repeated-measures design. OBJECTIVES: To quantify electromyographic (EMG) muscle activity of the infraspinatus, teres minor, supraspinatus, posterior deltoid, and middle deltoid during exercises commonly used to strengthen the shoulder external rotators. BACKGROUND: Exercises to strengthen the external rotators are commonly prescribed in rehabilitation, but the amount of EMG activity of the infraspinatus, teres minor, supraspinatus, and deltoid during these exercises has not been thoroughly studied to determine which exercises would be most effective to achieve strength gains. METHODS AND MEASURES: EMG measured using intramuscular electrodes were analyzed in 10 healthy subjects during 7 shoulder exercises: prone horizontal abduction at 100 degrees of abduction and full external rotation (ER), prone ER at 90 degrees of abduction, standing ER at 90 degrees of abduction, standing ER in the scapular plane (45 degrees abduction, 30 degrees horizontal adduction), standing ER at 0 degrees of abduction, standing ER at 0 degrees of abduction with a towel roll, and sidelying ER at 0 degrees of abduction. The peak percentage of maximal voluntary isometric contraction (MVIC) for each muscle was compared among exercises using a 1-way repeated-measures analysis of variance ($P<.05$). RESULTS: EMG activity varied significantly among the 7 exercises. Sidelying ER produced the greatest amount of EMG activity for the infraspinatus (62% MVIC) and teres minor (67% MVIC). The greatest amount of activity of the supraspinatus (82% MVIC), middle deltoid (87% MVIC), and posterior deltoid (88% MVIC) was observed during prone horizontal abduction at 100 degrees with full ER. CONCLUSIONS: Results from this study provide initial information to develop rehabilitation programs. It also provides information helpful for the design and conduct of future studies.

Johnson GR, Pandyan AD, Anand D (2005). The activity in the three regions of the trapezius under controlled loading conditions- an experimental and modelling study. *Clin Biomechanics* 20: 155-161.

Background. There is a degree of conflict in the literature regarding the biomechanical role of the three regions of trapezius. It is suggested that some of this may result from a lack of experiments using a well defined loading regime. Objectives. To study the activity of the three regions of trapezius under controlled load in order to gain further insight into its role in shoulder biomechanics. Design. The emg activity of the three regions of trapezius was studied on five subjects using a specially designed test system which allowed the application of either a uniaxial shrug force or a pure couple in the coronal plane. Methods. Test rigs were designed and constructed to measure isometric loads applied by shoulder shrugging and isometric pure moments produced in coronal plane abduction and adduction. Surface EMG of the three regions of trapezius was performed simultaneously with loading. Results. The activity of upper trapezius was always present but changed little with the type of loading. Middle trapezius was dominant during both shrug and abduction whereas the lower fibres predominated during adduction. Conclusions. The use of a test system applying defined loading at the shoulder allows the detail analysis of trapezius muscle activity. The reproducible technique can be extended to other shoulder muscles. Relevance: The biomechanics of the shoulder calls for detailed analysis of the activity of all the interacting muscles. This paper describes a technique which allows study of muscle activity under carefully defined loading.

Ekstrom RA, Donatelli RA, Soderberg GL (2003). Surface electromyographic analysis of exercises for the trapezius and serratus anterior muscles. *J Orthop Sports Phys Ther* 33: 247-258.

STUDY DESIGN: This study used a prospective, single-group repeated-measures design to analyze differences between the electromyographic (EMG) amplitudes produced by exercises for the trapezius and serratus anterior muscles. OBJECTIVE: To identify high-intensity exercises that elicit the greatest level of EMG activity in the trapezius and serratus anterior muscles. BACKGROUND: The trapezius and serratus anterior muscles are considered to be the only upward rotators of the scapula and are important for normal shoulder function. Electromyographic studies have been performed for these muscles during active and low-intensity exercises, but they have not been analyzed during high intensity exercises. METHODS AND MEASURES: Surface electrodes recorded EMG activity of the upper, middle, and lower trapezius and serratus anterior muscles during 10 exercises in 30 healthy subjects. RESULTS: The unilateral shoulder shrug exercise was found to produce the greatest EMG activity in the upper trapezius. For the middle trapezius, the greatest EMG amplitudes were generated with 2 exercises: shoulder horizontal extension with external rotation and the overhead arm raise in line with the lower trapezius muscle in the prone position. The arm raise overhead exercise in the prone position produced the maximum EMG activity in the lower trapezius. The serratus anterior was activated maximally with exercises requiring a great amount of upward rotation of the scapula. The exercises were shoulder abduction in the plane of the scapula above 120 degrees and a diagonal exercise with a combination of shoulder flexion, horizontal flexion, and external rotation. CONCLUSION: This study identified exercises that maximally activate the trapezius and serratus anterior muscles. This information may be helpful for clinicians in developing exercise programs for these muscles.

Lister J, Del Rossi G, Fangchao M, Stoutenberg M, Adams JB, Tobkin S, Signorile JF (2007). Scapular stabilizer activity during bodyblade, cuff weights, and thera-band use. *J Sport Rehabil* 16: 50-67.

There are numerous ways to overload the scapular stabilizers. Objectives: To assess scapular stabilizer activity using the Bodyblade and other traditional training devices. Design: Repeated measures analysis of surface EMG data collected from the upper trapezius (UT), lower trapezius (LT), and serratus anterior (SA) during shoulder flexion and abduction using Bodyblade®, cuff weight, and Thera-Band resistance. Setting: Laboratory. Participants: Thirty collegiate athletes (20. 0 ± 1. 7 years). Intervention: Participants performed 10 repetitions of shoulder flexion and abduction. Main Outcome Measures: For each movement, normalized root mean square values (NrmsEMG) were computed for each muscle during each repetition under each training condition. Data were analyzed using 3 (condition) x 10 (repetition) repeated measures ANOVAs. Results: During shoulder flexion and abduction, the NrmsEMG of the UT, LT, and SA were significantly greater when using the Bodyblade than the Thera-Band or cuff weight. Conclusion: The Bodyblade produces greater scapular activity than traditional resistance techniques.

Myers JB, Yan-Ying J, Hwang JH, Mc Mahon PJ, Rodosky MW, Lephart SM (2004). Reflexive muscle activation alterations in shoulders with anterior glenohumeral instability. *Am J Sports Med* 32: 1013-1021.

Background: Patients with glenohumeral instability have proprioceptive deficits that are suggested to contribute to muscle activation after alterations Hypothesis: Muscle activation alterations will be present in shoulders with anterior glenohumeral instability. Study Design: Posttest-only control group design. Methods: Eleven patients diagnosed with anterior glenohumeral instability were matched with 11 control subjects. Each subject received an external humeral rotation apprehension perturbation while reflexive muscle activation characteristics were measured with indwelling electromyography and surface electromyography Results: Patients with instability demonstrated suppressed pectoralis major and biceps brachii mean activation; increased peak activation of the subscapularis, supraspinatus, and infraspinatus; and a significantly slower biceps brachii reflex latency. Supraspinatus-subscapularis coactivation was significantly Suppressed in the patients with instability as well. Conclusions and Clinical Relevance: In addition to the capauloligamentous

deficiency and proprioceptive deficits present in anterior glenohumeral instability, muscle activation alterations are also present. The suppressed rotator cuff coactivation, slower biceps brachii activation, and decreased pectoralis major and biceps brachii mean activation may contribute to the recurrent instability episodes seen in this patient group. Clinicians can implement therapeutic exercises that address the suppressed muscles in patients opting for conservative management or rehabilitation before and after capsulorraphy procedures.

Stone JA, Prtin NB, Lueken JS, Timm KE, Ryan EJ (1994). Upper extremity proprioceptive training. *J Athletic Training* 29:15-18.

Proprioception following lower extremity injuries is commonly recommended, but there is little information on proprioception training following upper extremity injuries. No studies have evaluated whether proprioception programs for athletes in open kinetic chain activities (gymnastics, swimming, kayaking, or rowing). In this paper, we provide a rationale for proprioception training for upper extremity injuries in athletes and the importance of analyzing the athlete's sport and activity for specificity of proprioception exercises. We then discuss one popular proprioception exercise, rhythmic stabilization, and propose several additional upper extremity proprioception exercises, along with instructions for the athletic trainer on how to direct the athlete through these exercises.