Part 1: Anatomy And Kinesiology of the Shoulder and Neck

Stabilization Of The Neck And Shoulder Regions

Dynamic Stabilizers Of The Neck

Deep Neck Flexors: longus cervicis, longus colli, longus capitis and omo- and thyrohyoideus

Primary Movers Of The Neck

Extensor Muscles of the Neck: Suboccipitals, cervical section of the erector spinae, upper part of trapezius and levator scapulae, multifidus.

Superficial Neck Flexors: Scalenes and SCM. The SCM will substitute for the longus colli in neck flexion. (Liebenson 1996)

Static Stabilizers Of The Shoulder

In addition to contributions to joint geometry the capsule, glenohumeral ligaments and labrum also act as static stabilizers of the glenohumeral joint. The labrum deepens the glenoid socket, effectively increasing stability by elevating the glenoid rim. The static restraints are generally lax during motion in the functional ranges, and the dynamic stabilizers maintain stability. At extremes of motion, when the ligaments and capsule become taut, both the static and dynamic restraints function to maintain glenohumeral stability. For example, the inferior glenohumeral ligament checks abduction and external rotation, as seen at late cocking phase of throwing.

Repetitive motions at the extremes of ranges (e.g. in the late-cocking phase of the pitching, end of backswing in golf) can lead to stretching of the static restraints. If either of the restraint mechanisms, static or dynamic, are unable to function properly, excessive translation, either subluxation or dislocation, of the humeral head can occur, resulting in injury. (Ticker 1995)

Dynamic Stabilizers Of The Shoulder

The dynamic stabilizers of the glenohumeral joint primarily include the muscles of the rotator cuff and long head of the biceps. These muscles promote maximal range of motion and transfer of energy during overhead motions, within the range of glenohumeral stability. When all four cuff muscles contract together, a compressive force is created which acts to keep the humeral head centered in the glenoid. The rotator cuff also prevents upward displacement of the humeral head in the glenoid. If its function becomes impaired, superior translation of the humeral head will occur resulting in impingement of the cuff under the coraco-acromial arch. (Blevins 1997)

The rotator cuff appears to function as a deep stabilizer, similar to the transverse abdominus and vastus medialis obliquus, with some evidence of disruption of its stabilizing function (onset of activation) in the presence of pain. Similarly, the serratus anterior, functioning as a dynamic stabilizer, also demonstrates altered function in painful shoulders. (Magarey 2003)

The primary scapular stabilizers include the elevators (upper trapezius, levator scapulae, rhomboids, lower serratus anterior), the depressors (mid and low trapezius), and protractors (serratus anterior, esp. the upper portion).

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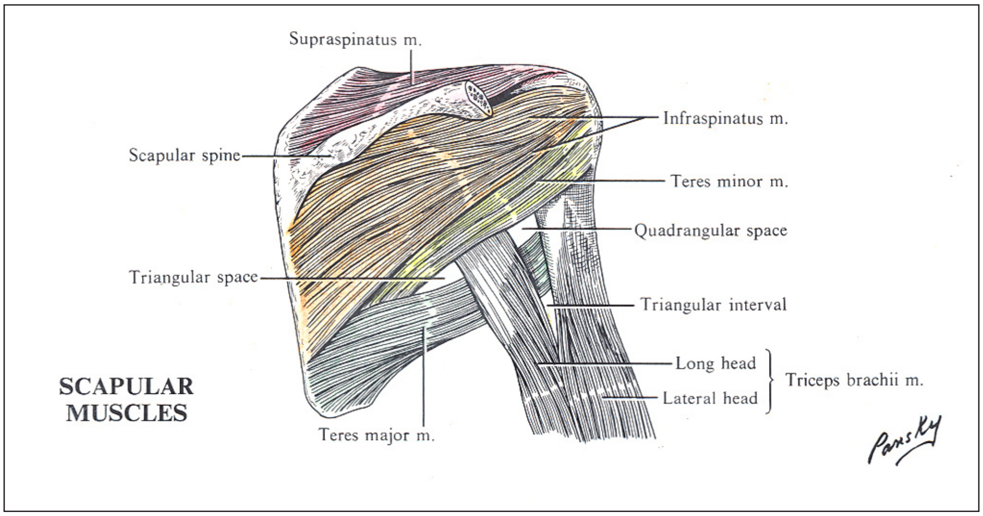
Functional Anatomy of the Shoulder

Rotator Cuff Muscles

Supraspinatus: Maintains the humeral head centered in the glenoid, serving as a dynamic stabilizer against superior translation of the humeral head. In addition the supraspinatus contributes to arm elevation.

Infraspinatus/Teres Minor Complex: The primary external rotators of the humerus, these two muscles assist in maintaining and stabilizing the glenohumeral articulation by pulling the humeral head posteriorly, inferiorly and compressing it into the glenoid.

Subscapularis: This internal rotator of the shoulder functions from the anterior direction, and can be less effective with the arm within 90° of abduction.



(Pansky, 1984)

Several studies have been performed to assess the role of the intact and deficient rotator cuff in arm elevation (Soslowsky 1997):

Concurrent application of forces by the supraspinatus or the infraspinatus/teres minor and subscapularis significantly reduced the required deltoid force over a wide range of motion by an average of 26% and 36% respectively. (May decrease superior shear forces.)

Paralysis of the supraspinatus resulted in a significant increase in the deltoid force required to initiate abduction. (May increase superior shear forces.)

Intact cuffs, cuffs with paralysis, and simulated cuff tears did not demonstrate an alteration in humeral translation in abduction provided that the infraspinatus tendon was functional.

The upward impinging force of the deltoid is counteracted by the subscapularis, infraspinatus, and teres minor, and the supraspinatus muscle acts in synergy with the deltoid.

Biceps, Long Head

Plays a role as a humeral head depressor, increases the shoulder's resistance to torsional forces in the vulnerable abducted and externally rotated position, and diminishes the stress placed on the inferior glenohumeral ligament (Ticker 1995)

Serratus Anterior

Muscle tests in which an attempt is made to de-rotate the scapula from an upwardly rotated position produces the greatest activity in the serratus anterior muscle. (Ekstrom 2005) The Serratus anterior is a very important scapular protractor and upward rotator. The upper part is more suited for protraction and the lower part for upward rotation of the scapula.

Trapezius

Reduction in activity of the lower part of the trapezius causes redistribution of muscle forces in the shoulder: Increased activity of rhomboid major (232%), rhomboid minor (175%), mid trapezius (201%), anterior deltoid and the medial serratus anterior. The levator scapula showed a decrease in muscle activity. (Palmerud 1998)

Upper Trapezius: An elevator of the scapula, tends to become shortened and overactive. In dysfunction, the upper trapezius often contracts before the deltoid (anterior) or the supraspinatus, creating a dysfunctional scapulohumeral rhythm. (Liebenson 1996)

Middle and Lower Trapezius: Stabilizes the scapula by adducting and depressing the scapula. "In the back pocket." Tends to be inhibited by hyperactive upper trapezius

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Scapula adductors

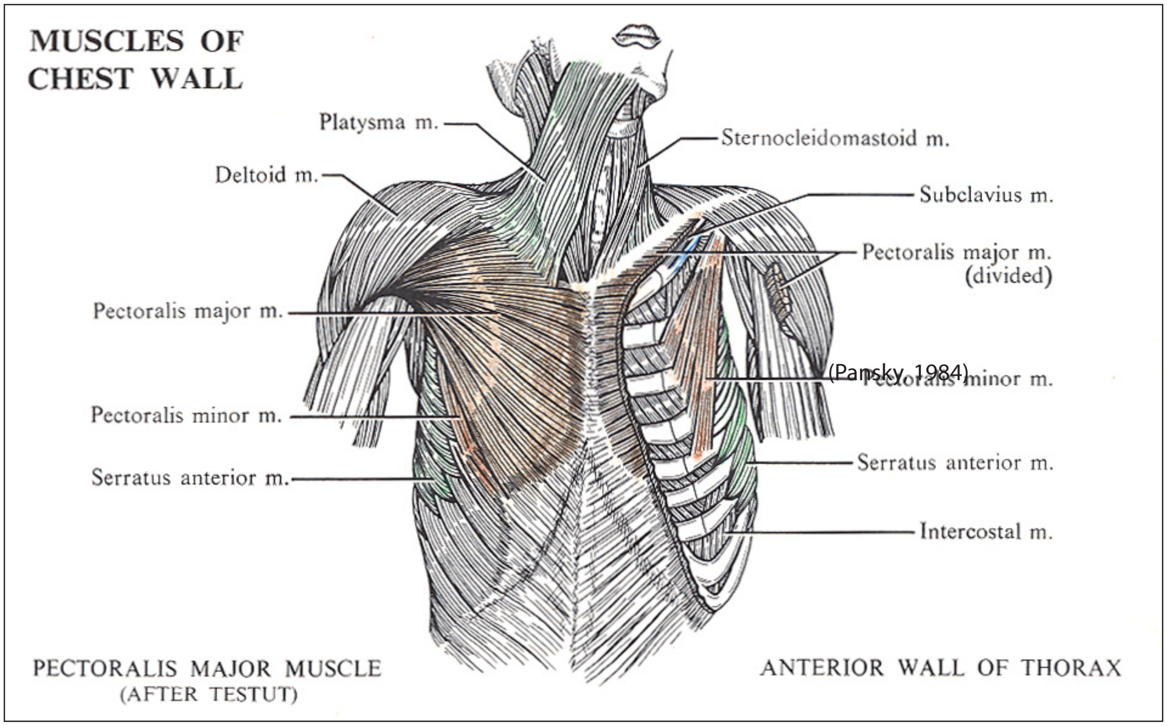
Latissimus dorsi, Rhomboids and Levator scapula. With no shortness of shoulder adductors, the shoulder joint can be completely flexed so that the whole upper extremity can lie on the table (lying supine) while the low back is flat on the table. (Kendall 1983)

Primary Movers Of The Shoulder

The pectoralis major, latissimus dorsi, deltoid (anterior, middle, and posterior heads), upper trapezius and teres major are the muscles primarily responsible for moving the arm. Infraspinatus/teres minor complex are the primary external rotators.

Strength Ratios

Several studies have compared agonist: antagonist strength ratios for shoulder adduction/abduction and internal/external rotation in upper extremities of both athletes and nonathletes. Although absolute strength was greater in athletes, the ratios were the same for both groups: 2:1 for adduction/ abduction and 3:2 for internal/external rotation. (Swanik 2002) Consequently, a 3:2 strength ratio has been established between internal and external rotation for upper extremity athletes and nonathletes.



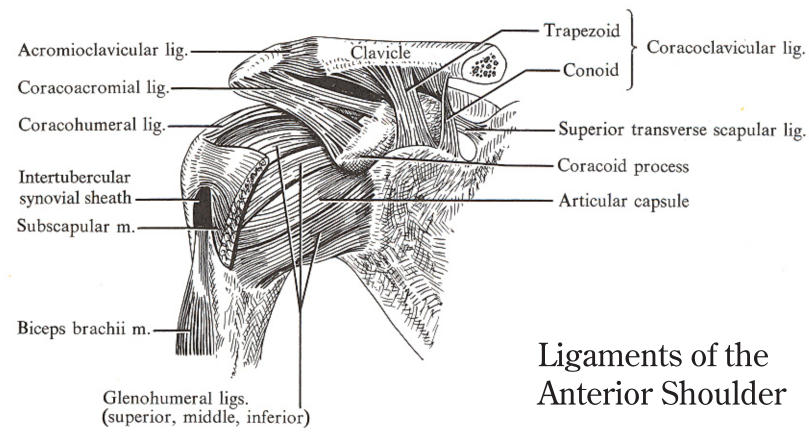
(Pansky, 1984)

Shoulder strength 'imbalance' is thought to occur naturally as a result of a greater cross-sectional diameter of the internal rotator muscles, resulting in higher force output when compared with the external rotators. In addition, shoulder-torque ratio adaptations have been found to occur in athletes in upper extremity sports such as swimming, baseball, and water polo, indicating that the shoulder internal rotators and adductors are 'superdeveloped' in comparison with external rotators and abductors. These changes have been attributed to the repetitive demands placed on the shoulder over the course of a season and a competitive career that predispose the shoulder to muscle dysfunction. (Swanik 2002)

Mechanisms of Shoulder Injury

Instability

The definition of instability of the shoulder is the inability to maintain the humeral head centered in the glenoid fossa. (Speer 1995) Landing on the out-stretched, externally rotated and abducted arm usually causes anterior shoulder dislocation. However, it may be difficult to pinpoint the initial event in cases of anterior subluxation or multidirectional instability. It is more likely that problems result from the repetitive forces involved in throwing or racquet sports. When these repetitive stresses are applied at a rate that exceeds tissue repair, progressive damage to the stabilizing structures of the shoulder can occur. Athletes with instability often present with vague complaints. They may report fatigue, discomfort, pain, apprehension, paresthesia, or numbness as their main problem and rarely describe any feeling of instability.



Ligaments of the Anterior Shoulder

(Pansky, 1984)

Subtle anterior glenohumeral instability can result in 'secondary' mechanical impingement and tensile overload and is frequently seen in throwing athletes: In a position of abduction and maximum external rotation as seen in the cocking phase of throwing, the anterior capsule and glenohumeral ligaments (particularly the inferior glenohumeral ligament) are the primary static stabilizers resisting anterior translation of the humeral head. Many throwers demonstrate increased external rotation and decreased internal rotation of their throwing arm compared with their nondominant arm. This is consistent with a lax anterior capsule and a tight, contracted posterior capsule. Tightening of the posterior capsule causes increased anterior translation of the abducted flexed arm and may increase anterior shear forces during throwing. (Blevins 1997) During deceleration phase of throwing, eccentric contraction of the supraspinatus and external rotators during follow-through may result in a traction injury of these tendons. This traction may be accentuated by increased translation experienced in the athlete with anterior instability. (Breazeale, 1997)

In individuals with instability demonstrate changes during movements of the shoulder:

- Suppressed pectoralis major and biceps brachii mean activation
- Slower biceps brachii reflex latency
- Decreased anterior and middle deltoid activity with shoulder flexion and shoulder abduction
- Increased peak activation of the subscapularis, supraspinatus, and infraspinatus
- Significantly suppressed supraspinatus-subscapularis coactivation. (Meyers 2004)
- Decreased supraspinatus muscle activity during abduction and scaption
- In both abduction and scaption, the supraspinatus demonstrated significantly less electromyographic activity from 30 degrees to 60 degrees($p < 0.05$) and less activity in the serratus anterior. (McMahon 1996)
- Decreased serratus anterior muscle activity during abduction, scaption and forward flexion

These disrupted muscle activities alter the force couple mechanism that exists between the deltoid and the rotator cuff muscles as well as scapular stabilization mechanisms vital to functional stability and coordinated movement patterns (Meyers 2004). The flexors of the shoulder joint (pectoralis major, short head of the biceps, coracobrachialis, anterior deltoid, and the subscapularis) are the most effective in resisting an anterior dislocation. As such, suppression of the pectoralis major may compromise anterior shoulder instability. Furthermore, it has been hypothesized that in a position of apprehension (90° abduction and external rotation), the pectoralis major may contribute to joint instability rather than its commonly believed stabilization role. (Meyers)

Throwers with anterior instability have demonstrated rotator cuff and parascapular muscle dysfunction, including inhibition of the internal rotators of the shoulder (Meyers 2004) and loss of normal synchronization of neuromuscular firing patterns (Lephart, 1997). During pitching, individuals with instability have shown increased compensatory supraspinatus and biceps brachii activity likely to accommodate for lack of glenohumeral stability. In addition, there was decreased subscapularis, pectoralis major, latissimus dorsi, and serratus anterior activity during the late cocking phase of pitching. (Meyers 2004) Inhibition of the subscapularis, pectoralis major, and latissimus dorsi function during late cocking may serve to accentuate the underlying laxity. In response, there is a compensatory increase in biceps and supraspinatus in an attepmt to restore anterior stability. (Lephart, 1997) The dynamic instability could also contribute to impingement as well as increase the eccentric load on the cuff tendons during the follow-through phase by permitting increased anterior translation of the humeral head. (Breazeale, 1997)

Key Points of Shoulder Instability

There is often tightening of posterior capsule.
The shoulder internal rotators exhibit weakness: Pect major, sub scapularis, and latisimus.
Biceps reactivity is slow and weak.
Dysfunctional subscapularis/supraspinatus coactivation.
Decreased activation of:
- Deltoid: Ant and med
- Supraspinatus @ 30° - 60° abduction
- Serratus anterior

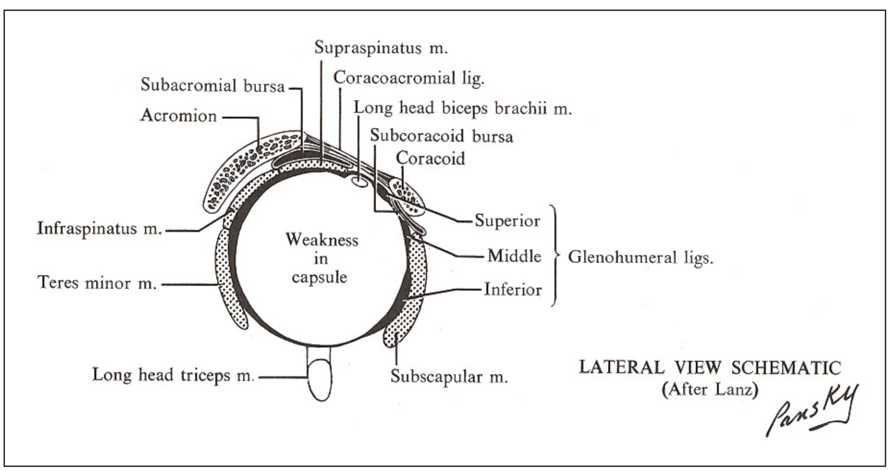
To stabilize: Avoid position of abduction and external rotation of shoulder. Focus initially on the shoulder flexors and internal rotators:
- Pect major
- Short head biceps
- Coracobrachialis
- Anterior deltoid
- Subscapularis

Impingement and Rotator Cuff Tears

Impingement tears of the rotator cuff are common after 40 years of age. Many patients over 40 have no prior history of trauma, and an attritional defect develops insidiously. Less than half of the patients with cuff tears can recall a specific event that initiated the symptoms. Pain is usually constant, worse at night and with overhead activities, and only mildly improved with anti-inflammatory agents. The pain is commonly referred to the base of the neck and the upper arm. The person finds it difficult and painful to reach the back pocket, loop a belt, or fasten a bra. (Wirth 1997)

Impingement of the rotator cuff occurs under the coraco-acromial arch as the arm is elevated resulting in inflammation, fibrosis and tearing of the cuff. Beginning with tendon strain and edema, cuff pathology can progress to inflammation, fibrosis, and, with time, partial- or full-thickness tears, ultimately leading to cuff-tear arthropathy. Rotator cuff impingement in an overhead athlete commonly develops secondary to tendon overload or glenohumeral instability. (Blevins 1997) Improper throwing mechanics, muscle fatigue and glenohumeral instability can increase the stress on the cuff. This can result in a 'vicious cycle' of cuff pathology: as stresses on the cuff increase to the point where it is no longer able to keep the head of the humerus centered in the glenoid, increased anterior and superior translation occurs resulting in mechanical impingement, collagen tensile failure, and further cuff dysfunction. (Blevins 1997)

Most overhead sports share a common basic pattern of motion consisting of preparatory phase of arm positioning progressing to forceful acceleration. Subsequent deceleration helps to reduce the force on the shoulder and avoid injury. The rotator cuff can be compromised at several stages in this process. Repetitive activity alone or in combination with instability places the cuff at risk for injury. In the late cocking phase of throwing, where the arm is in 90 degrees abduction and in maximum external rotation, the posterior portion of the supraspinatus tendon and the anterior aspect of the infraspinatus can be pinched between the humeral head and posterosuperior glenoid rim. Increased anterior humeral head translation, altered scapular mechanics, improper throwing mechanics, and fatigue of the shoulder musculature could increase this internal impingement.



(Pansky, 1984)

During scaption, patients with impingement show decreased scapular upward rotation during the first third of movement, increased anterior tipping throughout the final two-thirds of motion, and increased scapular medial rotation under loaded conditions and the upper and lower trapezius muscle activities increase throughout the final two-thirds of motion. The serratus anterior muscle shows decreased activity during all loads and phases of movement. (Ludewig 2000)

Tensile Overload

In throwing athletes the rotator cuff can be primarily stressed beyond its ability to adapt and heal resulting in tendon collagen failure, inflammation and degeneration. The resulting cuff dysfunction leads to increased glenohumeral translation and secondary impingement. Partial thickness tears from tendon overload most frequently develop on the intra-articular side of the cuff. (Blevins 1997)

Macrotrauma

Rotator cuff injury may occur in athletes as the result of a direct blow to the shoulder. Direct blows are likely to involve a contusion of the cuff with acute swelling an inflammation. The subacromial bursa also appears to be involved and may become acutely swollen and inflamed and chronically fibrotic and thickened. Athletes with rotator cuff contusion and acute impingement often present a clinical picture mimicking a rotator cuff tear. (Blevins 1997)

Upper Cross Syndrome

In the upper crossed syndrome there is imbalance in the following muscle groups:

1. Between the upper and lower fixators of the shoulder girdle (i.e. the upper trapezius, levator scapulae and frequently the scalenes on the one hand, and the lower trapezius and the serratus anterior on the other).
2. Between the pectorals and the interscapular muscles
3. Between the deep neck flexors (longus cervicis, longus capitis and omo- and thyrohyoideus) on the one hand, and the neck extensors (cervical section of the erector spinae, upper part of trapezius and levator scapulae) on the other.

If the lower fixators of the shoulder girdle are weak, the upper fixators must become hyperactive and tense. Hyperactivity of the pectoralis muscle produces rounded shoulders and forward drawn shoulder, neck and head; weak deep neck flexors with short extensors produce hyperlordosis of the upper cervical spine. Furthermore, there can be interrelations between upper and lower crossed syndromes and dysfunction at the hand and elbow. (Lewit 1999)

Table 18.19. Upper Crossed Syndrome

Imbalance in the following pairs of muscles:
- Weak lower and middle trapezius and short upper trapezius and levator scapulae
- Weak deep neck flexors and short suboccipitals and sternocleido-mastoid
- Weak serratus anterior and short pectoralis major

Table 18.20. Postural Signs of Upper Crossed Syndrome

Postural Finding	Dysfunction
Round shoulders	Shortened pectorals
Forward-drawn head	Kyphotic upper thoracic spine
C0-C1 hyperextension	Shortened suboccipitals
Elevation of shoulders	Shortened upper trapezius and levator scapulae and weak lower and middle trapezius
Winging of scapulae	Weak serratus anterior

Liebenson C. Rehabilitation of the Spine 1996

The Shoulder In Sports - The Mechanics of Throwing

Throwing is the primary sport-specific activity of the upper extremity used by athletes. Attention to this activity provides insight to

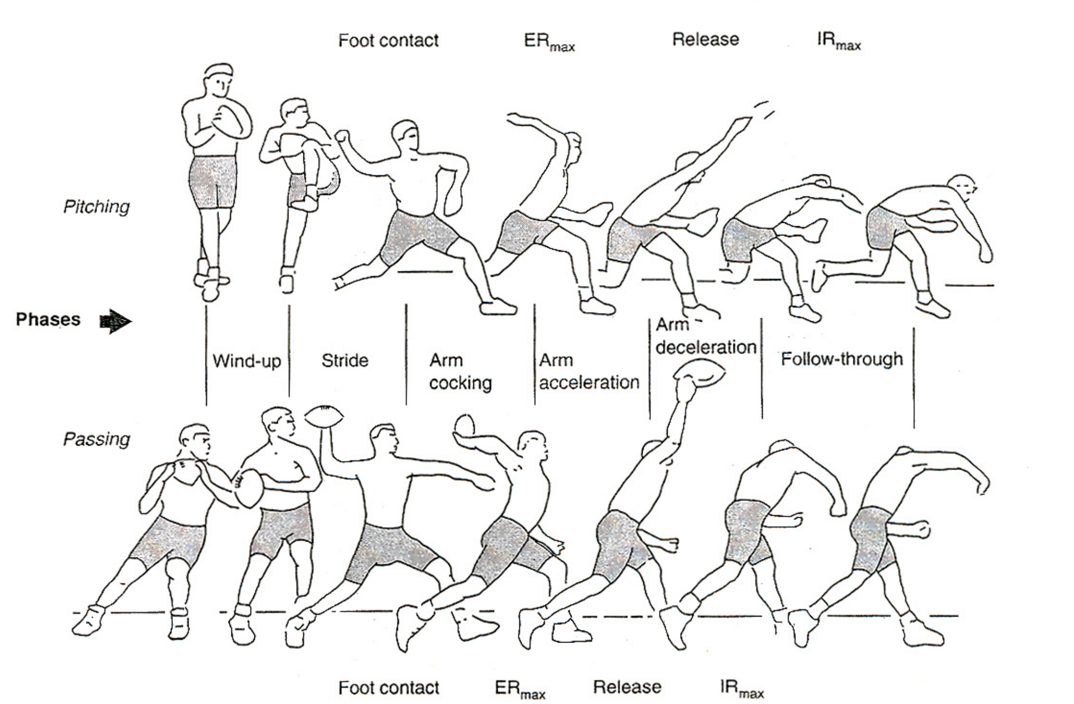


Fig. 1. The 6 phases of overhand throwing for baseball pitching and football passing: wind-up, stride, arm cocking, arm acceleration, arm deceleration, and follow-through. Instances of foot contact, maximum shoulder external rotation (ER_{max}), ball release, and maximum shoulder internal rotation (IR_{max}) are indicated (from Fleisig et al.).

many other upper body movements. Here we will look at the overhand throw as seen in the baseball pitch.

Wind-up

The objective of the wind-up is to put the thrower in a good starting position. Includes body rotation and ends with maximum knee lift of the lead knee.(Fleisig 1996) The deltoid is active during the wind-up phase. (Blevin, 1997)

Stride

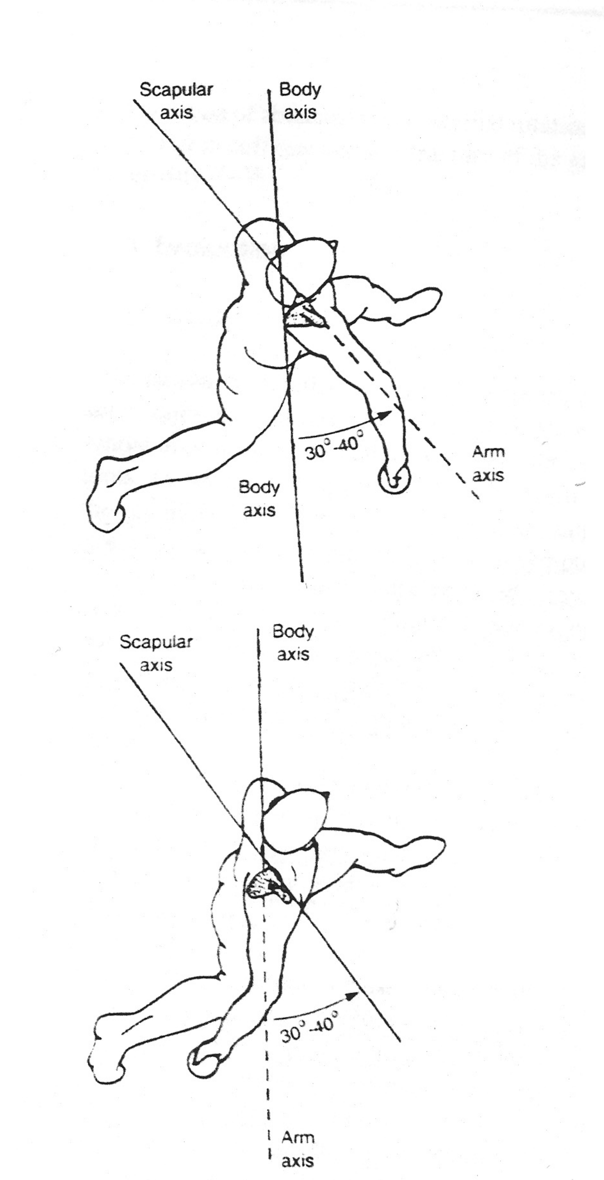
The thrower generates linear velocity by driving the lead side toward the target. It involves stretching of the body which creates potential energy and stimulates the stretch reflex. Forward movement is initiated by hip abduction of the stance leg, followed by knee and hip extension. This phase ends when the lead foot contacts the ground.

The deltoid and supraspinatus are responsible for abducting the shoulder and holding the arm in position; the rotator cuff muscles help maintain proper humeral head position in the glenoid fossa; upper trapezius and serratus anterior upwardly rotate and position the glenoid for the humeral head (improper positioned scapula can lead to impingement and shoulder control problems); elbow flexors control elbow flexion; and wrist and finger extensors move the wrist into hyper extension. (Fleisig 1996)

Arm Cocking

In this phase, the body rapidly rotates forward while the arm achieves maximal abduction, external rotation and extension. Significant torques and forces are placed on the shoulder restraints at this extreme range of motion and stability is imposed by both static and dynamic stabilizers. There is peak activity of the rotator cuff to both externally rotate and stabilize the humeral head. The inferior glenohumeral ligament is involved with high levels of strain. (Blevin, 1997)

The quadriceps of the lead leg initially contract eccentrically to decelerate knee flexion. Near the time of lead foot contact, the pelvis begins to rotate to face the target. Shortly after pelvis rotation, upper torso rotation is initiated. Maximum angular velocity of upper torso rotation is approximately twice that of the pelvis. Torso rotation and hyperextension of the lumbar trunk contribute



Hyperangulation. Angular relationships of the body axis, scapula and arm are shown during the acceleration phase of throwing. In the pitcher with proper mechanics, the scapula and arm are colinear (top). Hyperangulation; the arm lags behind the scapula, which increases stress on the anterior capsule, angular torques and internal impingement (bottom). (Blevin 1997)

to abdominal muscle stretching. (Fleisig 1996)

The shoulder girdle muscles stabilize the scapula and properly position the glenoid. Dysfunction of these muscles contribute to additional stress of the anterior shoulder stabilizers. To resist glenohumeral distraction, compressive force is produced by the rotator cuff muscles. Shoulder internal rotation torque to decelerate external rotation is produced by eccentric contractions of the internal rotators. Posterior rotator cuff muscles resist anterior humeral head translation. Anterior muscles generate anterior shear force and horizontal adduction torque to resist posterior translation of the humerus and keep the arm moving forward. (Fleisig 1996)

Shortly before the end of the arm cocking phase elbow extension is initiated. It is critical for the elbow to begin extending before the shoulder begins to internally rotate. By extending the elbow, the moment of inertia is reduced, allowing for greater shoulder internal rotation velocity. Arm Cocking ends with shoulder at maximum external rotation. (Fleisig, 1996)

Acceleration

This is the explosive portion of the throw. Further body motion and contraction of the internal rotators, including the pectoralis and latissimus muscles, leading to internal rotation of the throwing arm. In the well-conditioned and trained professional pitcher this phase does not activate the entire rotator cuff, but selectively activates the subscapularis. However, in the amateur thrower, all of the rotator cuff muscles and long head of biceps are activated to generate additional power. (Blevin, 1997)

The trunk flexes forward and is enhanced by stabilization from the lead knee, about which the trunk rotates. The throwing arm remains abducted approximately 90° throughout the acceleration phase, implying that this is a strong position for the shoulder to function.

The shoulder internal rotators contract concentrically to help produce an extremely high maximal internal rotation velocity. The rotator cuff, trapezius, serratus anterior, rhomboids and levator scapula are all highly active creating crucial humeral head control and scapula stabilization. Maximal internal rotation velocity occurs near the time of ball release. Ball velocity is generated primarily by body segments other than the upper extremity; namely the legs, hips and trunk. The final segment to impart force to the ball is the hand. (Fleisig, 1996)

Arm Deceleration

This is the short time from ball release to maximum shoulder internal rotation. The trunk and hips continue to flex, the lead knee and throwing elbow extend (just short of full extension), shoulder internal rotation continues until it reaches approximately 0° (neutral position).

Shoulder posterior force is produced by the infraspinatus, supraspinatus, teres major and minor, latissimus dorsi and posterior deltoid. The teres minor produces the highest activity of all the glenohumeral muscles during this phase. (Fleisig, 1996)

Follow-through

Begins at time of maximum shoulder internal rotation and ends when the arm completes its movement across the body and the athlete is in a balance position. A long arc of movement and transferring most of the weight to the lead leg allows energy to be absorbed by the large musculature of the trunk and legs. (Fleisig, 1996)

During follow-through, after the ball has been released, deceleration of the arm and body takes place. Only part of the kinetic energy generated in the previous stages is transferred to the ball at release. The remaining portion of energy must be absorbed and properly dissipated. All major muscle groups eccentrically contract to accomplish this result. Injury to the posterior glenohumeral joint structures and eccentrically contracting muscles can result in this final phase of the throwing motion. (Ticker 1995)

The serratus anterior is the most active scapular rotator in this phase. (Fleisig, 1996) During follow-through, the supraspinatus, infraspinatus and teres minor aid in decelerating the humeral head and stabilizing it in the glenoid. It is during deceleration that the highest forces are measured: the rotator cuff acts eccentrically and very high forces are created. Throughout the entire throwing motion the subscapular stabilizers (serratus anterior, trapezius, and rhomboids) contribute by positioning the scapula for optimum stability. (Blevins 1997)

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Muscle Firing Patterns During Various Sport Activates

Windmill Soft Ball Pitch

The supraspinatus muscle fires maximally during arm elevation from the 6 to 3 o'clock position phase, centralizing the humeral head within the glenoid. The posterior deltoid and teres minor muscles act maximally from the 3 to 12 o'clock position phase to continue arm elevation and externally rotate the humerus. The pectoralis major muscle accelerates the arm from the 12 o'clock position to ball release phase. The serratus anterior muscle characteristically acts to position the scapula for optimal glenohumeral congruency, and the subscapularis muscle functions as an internal rotator and to protect the anterior capsule. Although the windmill softball pitch is overtly different from the baseball pitch, several surprising similarities are revealed. The serratus anterior and pectoralis major muscles work in synchrony and seem to have similar functions in both pitches. Although the infraspinatus and teres minor muscles are both posterior cuff muscles, they are characteristically uncoupled during the 6 to 3 o'clock position phase, with the infraspinatus muscle acting more independently below 90 degrees. Subscapularis muscle activity seems important in dynamic anterior glenohumeral stabilization and as an internal rotator in both the baseball and softball throws.

Golf Swing

In the trailing arm, the levator scapulae elevates while the rhomboid muscles retract the scapula during takeaway; both then stabilize the scapula through the remainder of the swing. In the leading arm, these muscles retract the scapula during forward swing and acceleration. The trapezius muscle in the trailing arm also demonstrates high activity during takeaway to aid in scapular retraction. In the leading arm, trapezius activity is high in forward swing and through the remainder of the swing to promote scapular retraction. The serratus anterior muscle activity is high in the trailing arm during forward swing and through the remainder of the swing to maximize scapular protraction. In the leading arm, the serratus anterior muscle has constant activity through all phases of the swing, which may explain the clinical scenario of muscle fatigue in high demand golfers. The golf swing and uncoiling action requires that the scapular muscles work in synchrony to maximize swing arc and clubhead speed.

Swimming – General

In non-injured swimmers, the upper trapezius is activated 217 ms prior to shoulder motion, followed by serratus anterior activation 53 ms after motion commences. Lower trapezius is not recruited until 349 ms after shoulder motion, when the arm has attained 15 degrees elevation. In injured swimmers, all three muscles on the injured side display significantly increased variability in the timing of activation, while the serratus anterior is significantly delayed in its activation on the non-injured side. A relationship does exist between shoulder injury and the temporal recruitment patterns of the scapular rotators, such that injury reduces the consistency of muscle recruitment. Furthermore, injured swimmers have muscle function deficits on their unaffected side. (Wadsworth 1997)

Breaststroke – Injured v/s Uninjured

The differences in muscle activity between the two groups of swimmers demonstrated an increase in the internal rotators in the group with painful shoulders. Injured swimmers also demonstrated a decrease in the teres minor, supraspinatus, and the upper trapezius muscles. These factors increase the risk of impingement. Both the serratus anterior and teres minor muscles in the swimmers with normal shoulders consistently fired at or above 15% manual muscle test throughout the breaststroke cycle and were thus subject to fatigue. Based on these results, exercises for the breaststroke swimmer should be directed toward endurance training of the serratus anterior and teres minor muscles while balancing the internal and external rotators of the shoulder as well as the deltoid and supraspinatus muscles. (Ruwe 1994)

Butterfly – Normal

Upon hand entry, the deltoids and rotator cuff muscles demonstrate activity as the humerus was abducts, extends, and externally rotates. The rhomboids and upper trapezius are also active, retracting and upwardly rotating the scapula, which positions the glenoid for the humerus. During propulsion, the pectoralis major and latissimus dorsi generate power. The subscapularis and teres minor are active to control humeral rotation. The serratus anterior help to pull the body over the arm by reversing its origin and insertion. The posterior deltoid completes humeral extension at the end of propulsion and begins to lift the arm out of the water. Then, the middle and anterior deltoids fire with the supraspinatus and infraspinatus to abduct and externally rotate the arm. The scapular muscles are also active, retracting the proximal portion of the scapula while protracting and upwardly rotating the distal tip. The glenoid then provides a platform for the humerus. Overall, the serratus anterior and the subscapularis maintain a high level of activation throughout the stroke; thus, these muscles are highly susceptible to fatigue and vulnerable to injury. (Pink 1993)

Butterfly – The Painful Shoulder

The posterior deltoid demonstrates more activity in the painful shoulders during hand entry while the upper trapezius and serratus anterior exhibited less activity. This alteration in muscle firing patterns allows for the humerus to be positioned for a wider hand entry, which decreases the pain of impingement of the supraspinatus on the coracoacromial arch. Correspondingly, there was significantly less activity in the supraspinatus. The teres minor and serratus anterior shows significantly less muscle action throughout pulling as they respectively fail to balance the humeral rotation and do not reverse their origins and insertions to pull the body over the arm. Also, the subscapularis and infraspinatus display increased activity in the painful shoulders as they depress the humeral head to avoid impingement. There are no significant differences between the two groups in the rhomboids, pectoralis major, latissimus dorsi, or the anterior and middle deltoids.

Baseball Batting

The two hamstring and the gluteal muscles have a similar pattern of high muscle activity during pre-swing and early swing, and then rapidly diminished. The vastus medialis demonstrates peak activity between 95 and 110% maximum muscle test (MMT) throughout the swing phases and follow-through. The erector spinae demonstrates activity from 85 to 185% MMT during the swing phases. The abdominal obliques show greater than 100% MMT during the swing phases and follow-through. The supraspinatus and serratus anterior show relatively low muscle activity (less than 40% MMT). These results show that batting is a sequence of coordinated muscle activity, beginning with the hip, followed by the trunk, and terminating with the arms. Power in the swing is initiated in the hip, and therefore exercises that emphasize such strength development are indicated. The maintained, high muscle activity in the trunk muscles indicates a need for back and abdominal stabilization and rotation exercises. The relatively low level of activity in the four scapulohumeral muscles tested indicated that emphasis should be placed on the trunk and hip muscles for a batter's strengthening program. (Shaffer 1993)

Tennis

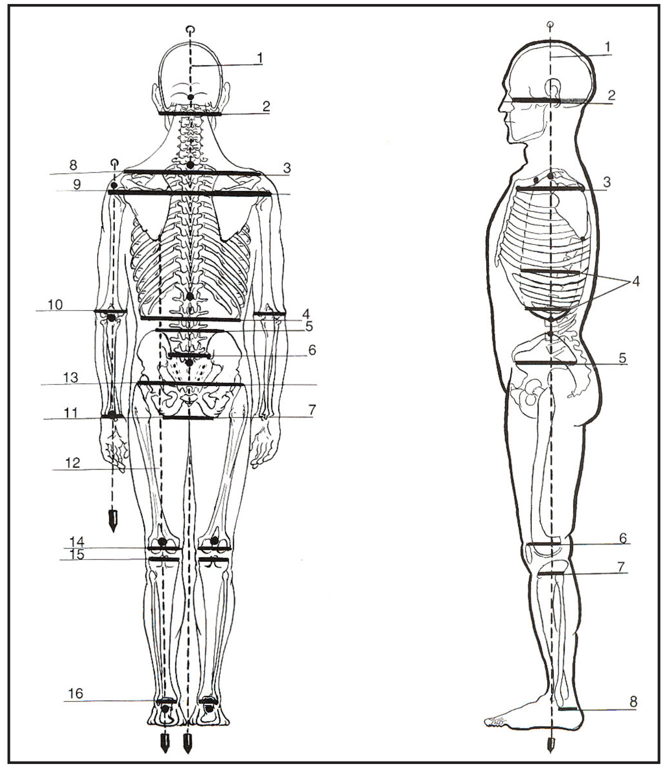
The subscapularis, pectoralis major, and serratus anterior display the greatest activity during the serve and forehand. The middle deltoid, supraspinatus, and infraspinatus are most active in the acceleration and follow-through stages of the backhand. The biceps brachii increases its activity during cocking and follow-through in the serve with a similar pattern noted in the acceleration and follow-through stages of the forehand and backhand. The serratus anterior demonstrates intense activity in the serve and forehand, thus providing a stable platform for the humeral head and assisting in gleno-humeral-scapulothoracic synchrony. (Ryu 1988)

Part 2: Functional Evaluation of Shoulder and Neck Stability

Mobility And Flexibility

Posture: Stand upright in a relaxed posture.

- Chin poking: Weakened deep neck flexors
- Rolled shoulders Shortened pectoralis, weakened scapular retractors
- Shoulder elevation: hypertonic upper trapezius, weakened lower trapezius
- Scapular winging; Weakened serratus anterior
- Head tilting: Unilateral hypertonicity, tonic neck reflex
- Arms forward with internal rotation: Shortened pectoralis major, weakened scapular retractors
- Thoracic Kyhosis: Upper cross syndrome, tightened abdominal flexors, weakened posterior chain



Lewit K. Manipulative Therapy in Rehabilitation of the Locomotor System, 1999

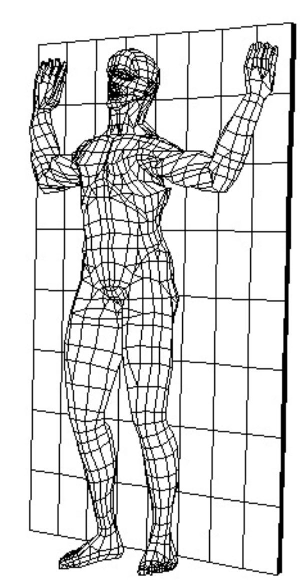
Coronal View Landmarks: External auditory canal, Acromion, greater trochanter, lateral condyle of the femur, a finger's breadth in front of the lateral maleolus.

Corner Lean: Stand facing the corner of two walls about a foot out, elbows and forearms on wall at 90° abduction.

Un able to touch chest to the walls in corner: Shortness of especially anterior chest musculature. Anterior shoulder pain may represent anterior instability. When this test is positive expect the client's posture to demonstrate chin poking, rolled shoulders with arms forward and turned in. There could be scapular winging and excessive thoracic kyphosis.

Wall Angel: Stand with back to wall, arms raised to 90° abduction and forearms at 90° and externally rotated. Feet about 3 inches from wall, with occiput, upper back, sacrum elbows and hands in contact with the wall.

- Unable to make contacts at shoulder, cervical or upper back range of motion: flexibility issues
- Pain/discomfort: Tissue overload from limited flexibility.
- Unable to flex lumbar spine and touch wall with low back: decreased upper back mobility.



Wall Angel

Functional Tests For The Neck And Shoulder

Supine Neck Flexion Test (Strength of the deep neck flexors): Lie supine, raise head as if touching chin to upper chest. This test can be substituted by careful observation of the client, observing for chin poking during activities.

- Chin poking: weakness of the deep neck flexors
- Excess shaking: early fatigue
- Not able to hold 10 seconds: note any pain/discomfort: weakness with compensatory overload

Shoulder Abduction: Standing or sitting, abduct shoulders to end range of motion.

- Early scapular elevation - upper trap overdominance
- Rhythm: Coordination of the muscles of stabilization
- Winging - Serratus Anterior
- Range of Motion: Multiple causes, note asymmetry

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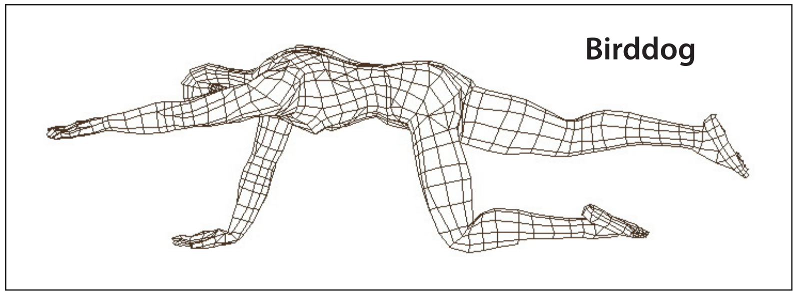
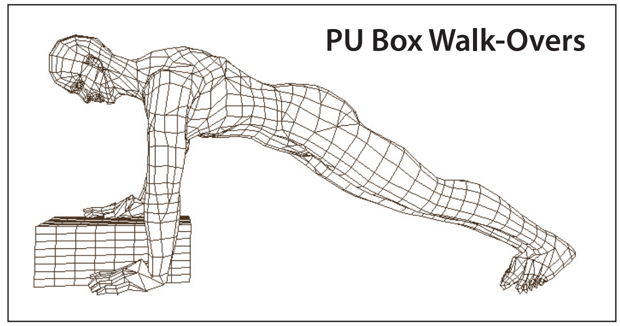
Birddog: Quadraped position, raise alternate arm/legs.

- Winging - Serratus Anterior
- Chin poking - Deep Neck Flexors
- Also watch for hip lifting as a weakness of trunk stabilization or glute max



Push Up: Standard on-the-toes/knees push-up, moving from top, down and from relaxed lying on floor, up. Greater challenge can be assessed by stepping back and forth over two lines at 16" or over boxes of various heights.

- Early elevation - Upper Trap overdominance, Mid/low Trap weakness/dysfunction
- Winging - Serratus Anterior
- Chin poking - Deep Neck Flexors
- Body alignment - Core



Internal/External Shoulder Rotation: manual muscle strength test at side, scaption and 90° abduction with elbow at 90° flexion.

- Internal:External strength ratio should be 3:2.
- During resisted internal rotation can exhibit scapular winging: serratus ant.

Manual Muscle Strength Tests For Shoulder Function

Trapezius: The unilateral shoulder shrug exercise was found to produce the greatest activity in the upper trapezius. For the middle trapezius, the greatest activity was 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 activity in the lower trapezius. (Ekstorm 2003) The upper traps tend to overdominate scapulohumeral movement and tend to hypertonicity. Because the mid and lower traps are sensitive to inhibition, they are the most important to test:

Middle Traps: Prone, arms at 3:00 and 9:00, thumbs up (ext rotation). Test by pressing the arms to floor.

Lower Traps: prone, arms overhead, thumbs up (ext rotation). Test by pressing the arms to floor.

Serratus ant: In certain clinical cases, exercises substantially activating the serratus with minimal upper trapezius activation are preferred. The standard push-up plus demonstrated the highest activation of the serratus (to 123%) and the lowest trapezius/serratus ratios during plus phases. (Ludwig 2004) The serratus anterior was maximally activated with exercises requiring a great amount of upward rotation of the scapula and with shoulder abduction in the plane of the scapula above 120 °, and diagonal exercise with a combination of shoulder flexion, horizontal flexion, and external rotation. (Ekstrom 2004)

This muscle is mostly tested in functional tests while watching for winging: Push-up, Shoulder abduction and internal rotation tests.

Subscapularis: Supine, elbows a 90° flexion, resist internal rotation. Test with elbow in three positions: at side, in scaption and at 90° of abduction.

Infraspinatus/teres Minor Complex: Supine, elbows a 90° flexion, resist external rotation. Test with elbow at side, at low scaption and at 90° of abduction.

At 90° abduction: Look for an Apprehension Sign, which is a signal of anterior instability, especially if apprehension is decreased with a Relocation Test.

Supraspinatus: Pouring-out-a-can-of-whatever-you-want posture: arm straight, internally rotated, and 90° scaption. Resist elevation.

This is also a Can Test for shoulder impingement: (+) with pain at the top of the shoulder joint.

Biceps: Supinated, with elbow at mid range, resist elbow flexion. Also with elbow straight, arm flexed, resist supination.

Latissimus Dorsi: With the arm slightly extended at the side and internally rotated. Force is exerted by pulling outward and forward, so that the patient adducts and extends the arm.

Pectoralis Major: Maximum strength is at scaption and 90° abduction, resisting the push at a diagonal towards the opposite hip.

There are two bellies:

Clavicular - resisting horizontal adduction

Sternal – at 135° abduction resisting the push at a diagonal to opposite hip.

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