The Role of the Scapula

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The role of the scapula has recently received renewed interest as knowledge of the shoulder and surrounding structures has increased. In normal upper-quarter function, the scapula provides a stable base from which glenohumeral mobility occurs. Stability at the scapulothoracic joint is dependent upon the surrounding musculature. These scapular muscles dynamically position the glenoid so that efficient glenohumeral movement can occur. The scapula has been described by several authors as a vital component in overhead throwing motion (4, 7, 8). Kibler has studied the position of the scapula and believes that alteration of normal positioning can lead to altered biomechanics of the shoulder (7). When weakness is present in the scapular musculature, normal scapular positioning and mechanics may become altered. Efficient concentric and eccentric activity of the musculature surrounding the shoulder is dependent on having strong anchor muscles to stabilize the scapula.

Without a strong, stable base position, the scapula may slide laterally, thereby allowing the glenoid fossa to become more “anteverted,” which will place excessive stress on the anterior structures (7). Saha has also described the antverted position as a possible component of the subluxation/dislocation phenomena in patients who have undergone repetitive microtrauma (9).

**FUNCTIONAL ANATOMY AND BIOMECHANICS**

It is important that the clinician have a thorough understanding of the muscles that control the scapula and normal scapular mechanics. Only through an understanding of normal biomechanics can the pathomechanics of injury or dysfunction be understood. When describing the position of the scapula, the point of reference is the glenoid.

**Serratus Anterior**

The serratus anterior is an important scapular stabilizing muscle. It takes origin from the first eight ribs and courses along the rib cage to insert along the medial aspect of the scapula. The upper portion of the serratus anterior insertion is spread along the medial border of the scapula, while the lower portion inserts into the inferior angle of the scapula. Innervation to the serratus anterior is provided by the long thoracic nerve, which arises from the ventral rami of the fifth and seventh cranial nerves. Due to the multiple attachment sites, the primary role of the serratus anterior is to stabilize the scapula during elevation and to pull the scapula forward and around the thoracic cage. Advancement of the scapula to an anterior position on the thoracic cage is termed protraction or scapular abduction. The term protraction is more frequently
used in describing this anterior movement in order to avoid confusion with shoulder abduction. The movement of protraction is involved with pushing and punching type activities.

Rhomboids

The rhomboids (major and minor) function to stabilize the medial border of the scapula. The rhomboids are very active in scapular adduction or retraction, which can be defined as backward rotation of the scapula toward the vertebral column. The rhomboid minor takes origin from the spinous process of the seventh cervical and first thoracic vertebrae and inserts into the medial border of the scapula near the base of the scapular spine. The rhomboid major originates from the second through fifth thoracic vertebrae and inserts into the medial border of the scapula just below the insertion of the minor. Innervation to both the rhomboid major and minor is provided by the dorsal scapular nerve. If rhomboid weakness is present, the scapula will be unable to achieve full retraction. Full retraction is essential not only for overhead throwing motion but also for swimming strokes such as the crawl. The inability to achieve the fully retracted position during the throwing or overhead motion can lead to increased stress on the anterior structures of the shoulder (7). Activities that involve a pulling motion may be affected by lack of rhomboid strength. Electromyographic analysis has demonstrated a high level of rhomboid activity during the acceleration phase of pitching (4). This suggests that the rhomboids are contracting eccentrically to provide stabilization to the medial border of the scapula during acceleration (4). Therefore, the strength of the rhomboids is vital in throwing and overhead arm movement. Strengthening this muscle group should be emphasized when rehabilitating patients with anterior instability.

Upper Trapezius/Lever Scapulae

The upper trapezius and levator scapulae muscles are suspensory muscles of the scapula. The upper trapezius originates from the superior nuchal line, the external occipital protuberance of the skull, and the seventh cervical vertebra. The upper trapezius fibers course downward to insert into the distal third of the scapula. Innervation to the upper trapezius is provided by the spinal accessory nerve. The levator scapulae originates from the posterior tubercles of the transverse processes of cervical vertebrae 1–4. The insertion of the levator scapula is along the medial border of the scapula at the level of the scapular spine. Innervation is provided by the cervical plexus with frequent contribution by the dorsal scapular nerve. Minimum upper trapezius electromyographic activity has been reported in quiet standing (10). Adding a weight to the hand or elevation of the scapula initiates a strong contraction of both the upper trapezius and levator scapula (3). The upper trapezius has also been shown to be constantly active during ambulation to perform its suspensory role (1). In addition to its suspensory function, the upper trapezius assists in upward rotation of the scapula, which is critical in the movement of the arm overhead. If the upward rotation of the scapula is not effective, subacromial impingement may occur.

Pectoralis Minor

The pectoralis minor is an anterior muscle that takes origin from the axial skeleton (second through sixth ribs) and inserts into the medial aspect of the coracoid process on the scapula. The pectoralis minor is innervated by the medial-lateral pectoral nerves. The pectoralis minor functions to perform several movements: abduction, depression, downward rotation, and upward tilt of the scapula.

With normal physiologic movement, the scapular muscles act in concert with one another. Because each muscle is made up of multiple fibers that course in different directions, each muscle may have multiple functions. The trapezius retracts and elevates the scapula. The rhomboids and levator scapulae primarily retract and rotate the scapula downward. The serratus anterior rotates the scapula upward and protracts the scapula.

An important force couple exists to allow forward rotation of the scapula. A force couple is the action of two forces acting in opposite directions to impose rotation about the axis (6). The lower fibers of the serratus draw the lower angle of the scapula forward to couple with the trapezius and levator scapulae in forward rotation (6). Inman et al also describe the role of the levator scapulae and upper trapezius in assisting with upward rotation of the scapula (5). They describe the levator scapulae as the upward force unit rather than the lower fiber of the serratus. The lower force unit is described as consistent activity of the fourth and fifth digitations of the serratus anterior. The seventh and eighth digitations display less activity in the last degrees of abduction, which allows the angle to remain in the coronal plane. As the serratus anterior and upper trapezius provide upward rotation and stabilization of the scapula, the deltoid is able to assert its action on the humerus and not the scapula (2). This coupling effect was confirmed by Mosely et al, who performed electromyographic analyses during several scapular exercises (8) (Table 1). The force couple provides an extremely important function with upward rotation of the acro-
EVALUATION OF SCAPULAR STABILITY

The important stabilization function of the serratus anterior is dramatically presented in patients with extreme weakness or damage to the long thoracic nerve. When carrying objects in front of the body, these patients will demonstrate severe winging of the scapula, which produces a strong contraction of the serratus anterior to prevent backward rotation of the scapula.

Scapular winging has been traditionally demonstrated by having the patient push against the wall with his hands just below the waist (Figure 1a). If the serratus anterior and other stabilizers are weak, the scapula will rotate backward or wing. Another method to demonstrate scapular winging is to ask the patient to forward flex the shoulder to 90° (Figure 1b). If the serratus anterior is not performing its stabilizing function, the most dramatic effect will be observed in the first 45° of elevation as the scapula seeks the optimal position to allow for efficient glenohumeral rotation. It is important to conduct a bilateral examination, since slight winging may be normal in individuals with normal hypermobility.

Current treatment techniques to increase scapular stability have been developed, and positive clinical results have been observed. The most dramatic effects have been seen in patients with significant scapular winging. The limiting factor in objectively identifying the significance of these clinical results has been the inability to accurately document deficits and improvements in strength of the scapular musculature. Kibler has described the lateral scapular slide measurement, which measures the ability of the scapular stabilizers to control the medial border of the scapula (7). An increase of 1 cm or more in side-to-side measurements was reported to correlate directly with symptoms of pain and decreased shoulder function. Reproducibility and reliability of determining the point of reference on the

<table>
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<tr>
<th>Muscle</th>
<th>Exercise</th>
<th>% of MMT</th>
<th>Function</th>
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<td>Retraction</td>
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<td></td>
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<tr>
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<td>Rowing</td>
<td>50%</td>
<td>Retraction</td>
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<td>ABD</td>
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<tr>
<td>Pectoralis minor</td>
<td>Press-up</td>
<td>75%</td>
<td>Depression</td>
</tr>
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</table>

MMT = manual muscle test.

Mowly (8) performed an EMG analysis during several rehabilitation exercises. The values reported were expressed as a percentage of a maximum isometric muscle test that was performed for each muscle.

**TABLE 1. Most efficient exercises for specific muscles.**

**FIGURE 1.** A) This position demonstrates winging of the scapula by having the patient push into the wall with the hands below the waist. The serratus anterior contracts to prevent backward rotation of the scapula. If weakness is present unilaterally, winging will be observed. B) This technique allows the clinician to view scapular winging during dynamic elevation of the arm. Resistance from the rubber tubing forces maximum contraction of the serratus anterior to stabilize the scapula. Weakness will be observed unilaterally as scapular winging. We have found this technique to be more effective in demonstrating lack of scapular stabilization.
scapula to measure movement is difficult to achieve. Isokinetic testing of protraction and retraction as a means to quantify scapular strength is currently underway. The early results of day-to-day reliability have been promising.

**SCAPULAR STRENGTHENING EXERCISES**

**Serratus Anterior**

Mosely has described the push-up with a plus as an effective method to strengthen the serratus anterior (8). This exercise is performed by having the patient perform a push-up with full scapular protraction at the top of a push-up (Figure 2). If patients are either unable to complete or tolerate this exercise, they may begin the push-up with a plus in the standing position with their hands against the wall (Figure 3a). The standing push-off progression allows the therapist to gently “push” the patient into the wall (Figure 3b). An efficient eccentric contraction is produced as the patient catches himself and decelerates.

**Quadruped stabilization** is another closed kinetic chain exercise that stimulates proper stabilization of the scapula (Figure 4). The goal of this exercise is for the patient to try to control scapular winging that may be present while the therapist provides manual resistance to the uninvolved arm.

The punching (standing or supine) motion is another effective exercise for strengthening the serratus anterior. Patients elevate their shoulders to 90° with the elbow extended and perform a punching motion to allow maximal protraction. Manual resistance can be provided to the anterior shoulder (Figure 5). Resistance may also be applied through the long axis of the arm. Additional forms of resistance can be provided through the use of dumbbells, the body blade (Hymanson, Inc., Playa Del Rey, CA), and surgical tubing (Figure 6). As previously mentioned, isokinetic devices that allow scapular protraction/retraction provide an aggressive means of strengthening the scapular musculature (Figure 7).

**Middle Trapezius/Rhomboïd**

Strengthening the middle trapezius and rhomboids begins with sim-
rhomboids is the bent-over lateral raise.

**Upper Trapezius/Lever Scapula**

The upper trapezius and levator scapula can be exercised by performing shoulder shrugs with tubing. This exercise may also be performed using hand-held dumbbells for resistance. We prefer rubber tubing over dumbbells in patients suspected of having an inferior to multidirectional instability at the glenohumeral joint. Long axis distraction, when using heavy dumbbells, may exaggerate the inferior glide of the humeral head and should be avoided. An alternative method of strengthening is the use of manual resistance on the top of the scapula and clavicle. This method removes the stress applied to the inferior capsule of the glenohumeral joint.

**Long axis distraction, when using heavy dumbbells, may exaggerate the inferior glide of the humeral head and should be avoided.**

**FIGURES 6A and B.** A punching motion in the standing position will strengthen the serratus anterior muscle. This device is a home exercise product (scapular strengthening kit—Breg, Inc., Carlsbad, CA) that assists in developing scapular strength. The patient is instructed to fully protract the scapula by reaching forward. The patient then slowly returns the hand to the starting position as he focuses on controlling the scapula.

**FIGURE 7.** Isokinetic protraction and retraction are performed with a new closed chain attachment (Biodex, Shirley, NY). This instrument will help to document weakness of the serratus and rhomboid musculature.

**FIGURES 8A and B.** The seated row exercise is excellent for aggressive strengthening of the rhomboids. Proper technique is important. Using the scapular strengthening kit, the subject reaches forward to allow full protraction, followed by full retraction of the shoulder blades. The elbows must remain tucked as the handle is pulled into the chest while the shoulder blades are pinched.

**Lower Trapezius/Pectoralis Minor**

Mosely showed a high level of electromyographic activity in the lower trapezius and pectoralis minor while performing the press-up exercise (8).

**CONCLUSION**

The shoulder must be considered a kinetic chain made up of several joints. The function of the scapula and surrounding musculature is vital to the overall normal function of the shoulder. Rotator cuff strengthening has been an obvious treatment for various pathologies. Since the origins of the rotator cuff...
muscles arise from the scapula, an effective exercise regime for rehabilitation should include improving strength and function of the muscles that control the position of the scapula. Weakness of these anchoring muscles may lead to altered biomechanics of the glenohumeral joint with resultant excessive stress imparted to the rotator cuff and anterior capsule. Advancement in the knowledge of biomechanics and electromyographic patterns of the shoulder have allowed us to develop strengthening exercises that maximally strengthen these "anchor" muscles. The three basic activities to remember when designing a scapular strengthening program are scapular pinches, shrugs, and punches. The choice and intensity of specific exercises are determined by pain and associated pathology.

Through proximal strengthening, many shoulder problems can be improved.

REFERENCES


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