Evaluation and Management of Scapular Dysfunction

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Abstract: The scapula plays an important role in shoulder function and requires both significant mobility and stability. Normal motion is 3-dimensional, and during arm elevation consists of upward rotation, posterior tilting, and external rotation as well as clavicular elevation and retraction. Examination should include visual observation, symptom alterations tests, testing of muscle strength, and flexibility of key structures including the pectoralis minor, posterior shoulder and thoracic spine. Treatment consists of graded resistive exercise, neuromuscular retraining, stretching, manual therapy, and taping where necessary. Although several studies suggest a relationship between abnormal scapular motion and symptoms, strong evidence directly supporting a causal relationship is lacking and further work is necessary to clarify this relationship.

Key Words: scapula, dyskinesis, shoulder

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Scapular dysfunction is a common clinical problem, and proper scapular motion and stability are considered to be crucial to normal function of the shoulder.[1] The scapula has somewhat competing functions, in that on one hand significant mobility is required to move through a substantial arc of motion but on the other hand it must be a stable base for arm function. This motion is required to maintain optimal muscle length-tension relationships and glenohumeral joint alignment during elevation of the arm. However, when loads are applied to the shoulder, typically through the hand, it must become a stable base for glenohumeral function. The goals of this paper are to briefly review normal scapular motion, describe key elements of examination for scapular dysfunction, and associated intervention strategies.

NORMAL SCAPULAR MOTION

Three scapular rotations are typically used to describe scapular orientation[2–4] and these are depicted in Figures 1A–C. Upward/downward rotation of the scapula is the motion that is greatest and easiest to observe, occurring around an axis that is perpendicular to the plane of the scapula. Anterior/posterior tilting occurs around an axis through the spine of the scapula. Posterior tilting involves the inferior angle of the scapula moving anteriorly and the superior border moving posteriorly, which is the normal motion associated with arm elevation. Anterior tilting, if excessive, appears as winging of the inferior angle. Scapular internal/external rotation occurs around a vertically oriented axis and external rotation involves the lateral border of the scapula moving away from the thorax. The scapula can also translate superiorly-inferiorly, which corresponds to clavicular elevation and depression (Fig. 1D). Scapular anterior-posterior translation corresponds to clavicular protraction and retraction, respectively (Fig. 1E). Therefore, the motions of "scapular elevation or depression" and "scapular protraction or retraction" really occur in conjunction with corresponding rotary motions at the sternoclavicular joint.

During elevation of the arm, there is a consistent pattern of scapular upward rotation, posterior tilting, and external rotation along with clavicular elevation and retraction.[4,5] In the first 30 degrees of arm elevation, there should be very little scapular motion with a much greater contribution from the glenohumeral joint than the scapulothoracic joint. Between 30 and 90 degrees of arm elevation there is scapular upward rotation but greater relative motion at the glenohumeral joint and very little titling or external rotation. After 90 degrees of arm elevation, the contribution from the glenohumeral joint and the upward rotation at the scapulothoracic joint become almost equal. Posterior tilting and external rotation motions are nonlinear, with the majority of these motions not occurring until after 90 degrees of arm elevation. Some researchers have found scapular internal rotation with arm elevation in the sagittal plane.[5] In an important biomechanical study, using bone pins in the clavicle, scapula, and humerus, Ludewig et al[5] demonstrated that significant rotational motion also occurs between the clavicle and the scapula at the acromioclavicular joint. During arm elevation the scapula upwardly rotates, posteriorly tilts, and internally rotates relative to the clavicle. One significant finding in this work was that the majority of scapular posterior tilting occurs at the acromioclavicular joint.

Scapular upward rotation is controlled primarily by a force couple between the upper and lower trapezius and the serratus anterior.[6,7] Although specific muscle activity associated with posterior tilting and external rotation has not been demonstrated directly, the lower fibers of the serratus anterior and lower trapezius are positioned to produce posterior tilting and the middle trapezius is positioned to produce external rotation. Weakness in these muscles after nerve injury has been clearly associated with scapular winging, which is attributable to excessive anterior tilting and scapular internal rotation.[8]

IS SCAPULAR DYSKINESIS RELATED TO SHOULDER PATHOLOGY?

Recognition of the biomechanical role of the scapula in normal shoulder function has led to several clinical studies attempting to associate abnormal scapular motion,

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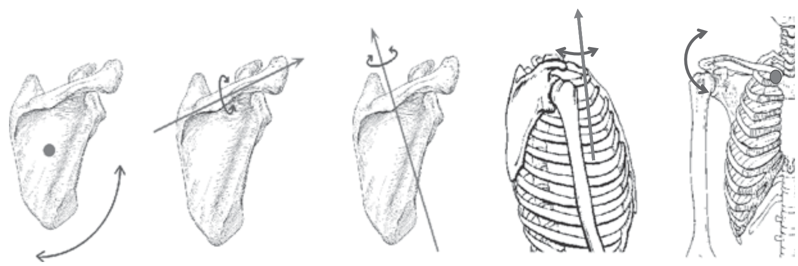

FIGURE 1. Scapular and clavicular rotations. A, Downward-upward rotation. B, Anterior-posterior tilting. C, Internal-external rotation. D, Clavicle depression-elevation. E, clavicle protraction-retraction.

so-called "scapular dyskinesis," with shoulder pathology such as shoulder impingement[3,9–13] or instability.[13] These studies have included several methods of capturing scapular motion including Moiré topography, electromechanical digitization, radiographic methods, magnetic resonance imaging, and electromagnetic tracking devices. Results of studies assessing 3-dimensional scapular motion in those with pathology have been inconsistent. Subjects with shoulder impingement have been found to demonstrate increased posterior tilting,[14,15] decreased posterior tilting,[3,9,11] decreased upward rotation,[9,11] increased upward rotation,[10,14] increased superior translation,[3,14] and increased internal rotation.[11,13] In addition to the variability of findings in these studies, the magnitude of differences between those with healthy shoulders and those with pathology are typically small, in the 3- to 5-degree range. Therefore, it is unclear whether these differences, although statistically significant, are really of clinical significance. Furthermore, in a recent study in overhead athletes, we failed to find an association between shoulder symptoms and abnormal scapular motion.[16] Therefore, despite some authors claiming a strong relationship between abnormal scapular motion and shoulder pathology,[17–19] the actual research evidence supporting this assertion is limited. Other clinical tests predicated on altering symptoms with manual scapula repositioning may hold promise in clarifying which patients truly have scapular dysfunction driving symptoms.[20–22]

EXAMINATION

The goal of scapular assessment is to identify abnormal scapular motion or positioning, determine any relationship between altered motion and symptoms, and identify underlying causative factors of movement dysfunction.[23–25] Clinical assessment of scapular dyskinesis is inherently challenging due to the 3-dimensional nature of scapular movement and soft tissue surrounding the scapula obscuring direct measurement of bony positioning. Several methods of identifying scapular dyskinesis have been described and although many of these tests have been shown to possess adequate levels of reliability, the validity of most tests remains questionable due to a lack of direct correlation with symptoms.[23] Clinical evaluation of scapular dysfunction should include 3 basic elements: (1) visual observation to determine the presence or absence of scapular dyskinesis in the symptomatic patient; (2) the effect of manual correction of dysfunction on symptoms; and (3) evaluation of surrounding anatomic structures that may be responsible for dyskinesis.[23]

The Lateral Scapular Slide Test is a static measurement of the side-to-side difference of the distance from the inferior angle of the scapula to the adjacent spinous process.[26] The measures are performed with the arms in 3 different positions and a side-to-side difference of > 1.5 cm should be considered pathological. This test has demonstrated fair to moderate levels of reliability and is easily applied in a clinical setting.[26,27] The major advantage of the lateral scapular slide test is its ease of use in the clinic. However, the validity of this test has been questioned because of the findings that both symptomatic and asymptomatic individuals will demonstrate asymmetry when measured in this manner.[28,29] In addition, it is possible to have symmetrical pathologic dyskinesis; therefore, validity is questionable when comparison is made only to the contralateral side. Furthermore, the static, and 2-dimensional nature of this test fails to fully assess the dynamic 3-dimensional motion found to occur with scapular movement.[16,28,30] This inadequacy of measurement along with questionable validity of results requires the use of other methods of scapular assessment during clinical examination.

Visual assessment schemes of classifying scapular dyskinesis have been developed in an attempt to resolve the issues with linear or static measures.[20,30,31] These methods involve classifying scapular movement during shoulder motion into normal or abnormal categories.

These measures are considered more functional in application and more inclusive with the ability to judge scapular movement in 3-dimensional patterns.

Kibler et al[20] were the first to describe a visually based system for rating scapular dysfunction that defined 3 different types of motion abnormality and 1 normal type. Reliability values for this system were too low to support clinical use and the test was subsequently refined in 2 studies using a simplified method of classification.[30,31]

The Scapular Dyskinesis Test is a visually based test for scapular dyskinesis that involves a subject performing weighted shoulder flexion and abduction movements while visual observation of the scapula is performed.[30] This test consists of characterizing scapular dyskinesis as absent or present and each side is rated separately. Dyskinesis is defined as the presence of either winging (prominence of any portion of the medial scapular border or inferior angle away from the thorax) or dysrhythmia (premature, or excessive, or stuttering motion during elevation and lowering) (Fig. 2). Interrater reliability of this test, after brief standardized online training http://www.arcadia.edu/academic/default.aspx?id = 15080, has been shown to be better than other previously described visual classification systems. Concurrent validity was assessed in a large group of overhead athletes and it was shown that those judged as demonstrating abnormal motion using this system

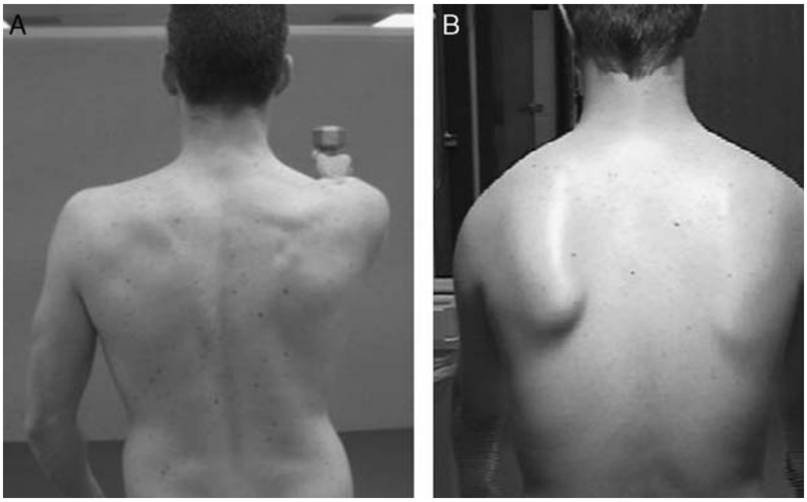

FIGURE 2. Scapular dyskinesis test. The test is performed by the patient flexing against a 3 or 5 pound weight and observing for scapular winging or dysrhythmia. A, Normal scapula. B, Obvious dyskinesis (winging) on the left.

also demonstrated decreased scapular upward rotation, less clavicular elevation, and less clavicular retraction when measured with 3-dimensional motion tracking.[16] Abnormalities were far more prevalent during shoulder flexion compared with frontal plane abduction. These results support the assertion that shoulders visually judged as having dyskinesis using this system, demonstrate distinct alterations in 3-dimensional scapular motion, particularly during flexion. However, while visually observed dyskinesis resulted in an altered 3-dimensional motion, subjects with dyskinesis were no more likely to report symptoms during sports.[16]

Uhl et al[31] used essentially the same criteria (winging or dysrhythmia) to classify any subject that demonstrated an abnormality in scapular motion into the "yes" classification and normal movement was classified as "no." They studied both symptomatic patients with various soft-tissue pathologies as well as an asymptomatic group. The "yes/no" test was found to have superior interrater reliability, and demonstrated better specificity and sensitivity values when using asymmetry found with 3-dimensional testing as a gold standard.[31] An important finding in this study was a higher frequency of dyskinesis during shoulder flexion in patients (54%) compared with asymptomatic subjects (14%), whereas no differences between groups were detected during scapular plane elevation.

Because scapular dyskinesis is a common finding in asymptomatic individuals, a basic problem in evaluation is deciding if the presence of scapular dyskinesis is an important abnormality perpetuating symptoms. The possibility exists that alterations of scapular motion could be compensatory strategies to avoid stress on pain-sensitive tissue. Symptom alteration tests have been developed as a way to infer scapular malposition is driving symptoms by manually redirecting scapular movement during provocation testing. If altering scapular position causes an immediate decrease in symptoms, this provides strong evidence that scapular dyskinesis is a contributing factor to shoulder symptoms. The 2 main symptom alteration tests are the scapular assistance test [21,26] and the scapular reposition (or retraction) test (SRT).[22,32]

The scapular assistance test involves manually assisting scapular upward rotation during shoulder elevation and determining this effect on pain.[33] This test was later modified by Rabin incorporating scapular posterior tilting as well (Fig. 3).[21] A positive test is when pain with elevation is either decreased or abolished during the assisted maneuver. This test has demonstrated acceptable levels of reliability and has been shown to be acceptable for clinical use.[21]

The SRT involves manually positioning and stabilizing the entire medial border of the scapula in a retracted position on the thorax.[33] This test was developed to help identify patients in which strength loss in shoulder elevation may be due to a loss of proximal stability of the scapula. The test is considered positive when the patient demonstrates a reduction of pain or an increase in shoulder elevation strength when the scapula is stabilized during isometric arm elevation in the scapular plane at 90 degrees.[24,33] Kibler et al[32] studied this test in symptomatic and asymptomatic subjects. Their findings demonstrated there was no change in pain levels and all subjects demonstrated improved strength output, regardless of symptoms.

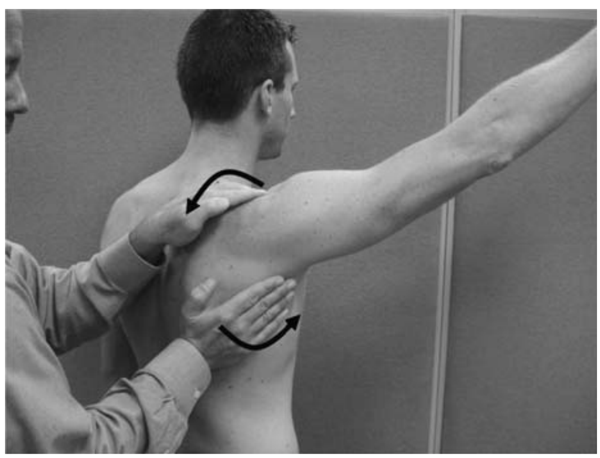

FIGURE 3. Scapular assistance test. The tester assists scapular upward rotation and posterior tilting during active elevation. A positive test occurs when symptoms are immediately decreased during active elevation.

FIGURE 4. Scapular reposition test. Isometric elevation strength is tested with manualpressure on the scapula encouraging posterior tilting and external rotation by forearm pressure on the medial border. A positive test occurs when strength is substantially increased or pain is decreased.

The Scapular Reposition Test (SRT) is a modification of the Scapular Retraction Test that involves emphasizing scapular posterior tilting and external rotation, but avoiding full scapular retraction (Fig. 4).[22] This modification was based upon previous investigations that have found a decrease in shoulder elevation strength with maximal active scapular retraction.[34] This test has demonstrated acceptable reliability and when performed on a large group of overhead athletes, roughly half of those with pain (46/98) during impingement testing had reduced pain and 26% had a substantial increase in isometric elevation strength. Therefore, this test may be helpful at identifying a subset of patients with shoulder pathology that may benefit from interventions designed to improve scapular muscle function.

Once an examiner determines that scapular dyskinesis is present and determines it is a contributing factor to the overall shoulder pathology, examination of the surrounding tissue should be performed to identify those factors that may be responsible for causing the altered scapular motion. Many structures have been implicated as possible contributors to the development of scapular dyskinesis. These include deficits in strength or motor control of scapular stabilizing muscles,[22,23,26,35] postural abnormalities,[36–38] and impaired flexibility.[17,39] Therefore, a comprehensive examination of all of these components is necessary.

Muscle strength of key scapular stabilizers can be assessed using standard positions and procedures described by Kendall et al[40] (Fig. 5). The key muscles to test are the serratus anterior, middle trapezius, and lower trapezius, as these are muscles that have been identified with key roles for scapular stabilization and movement.[24,35,41–44] A key concept in testing these muscles is that even though resistance is applied through the arm, weakness is identified by early "breaking" of the scapula rather than the arm. In patients with rotator cuff or deltoid weakness, the arm may need to be supported and resistance applied directly to the scapula to accurately determine scapular muscle weakness.

Many authors have suggested that forward head posture and increased thoracic kyphosis may contribute to scapular protraction and lead to adaptive shortening of postural muscles or muscular strength imbalances.[36,38,45,46] A protracted scapular position may be associated with a narrowed subacromial space[47,48] and a flexed thoracic spine and forward shoulder position alters scapular motion and results in diminished force output with elevation.[36] From the lateral view, the presence of forward head or protracted shoulder posture can be identified by either the external auditory meatus or the acromion being anterior to a line that represents the midline of the trunk.[40]

Adaptive shortening of the pectoralis minor muscle has been identified as a contributor to abnormal scapular kinematics and implicated as a factor that may contribute to shoulder impingement syndrome.[39,49] Sahrmann[49] has described an assessment method for pectoralis minor length that involves taking a linear measurement with the patient supine from the treatment table to the posterior aspect of the acromion, with any measurement > 2.54 cm suggesting tightness. Although highly reliable, some have questioned the validity of this method as it failed to discriminate those with shoulder pain.[50] Another assessment method that has been described involves using a tape measure or caliper to record the linear distance between the anatomic origin and insertion of the pectoralis minor muscle.[51] This measurement was found to have satisfactory intrarater reliability (intraclass correlation coefficient = 0.82 to 0.87) and good concurrent validity; however, its practicality for routine clinical use is questionable. This linear measure requires careful palpation and, once obtained, must be normalized to the size of the individual and a threshold for "tightness" has not been established.

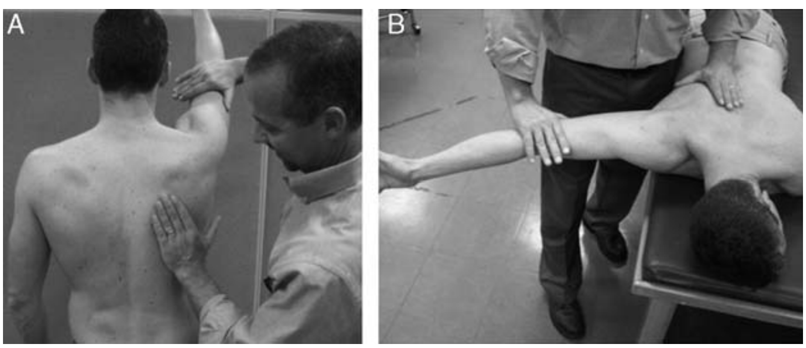

FIGURE 5. Manual muscle tests of key scapular muscles. A, Serratus anterior; (B) middle trapezius. With both tests the critical feature is to monitor motion of the scapula during resistance to assess for "breaking" of the scapula. Patients with weakness of the rotator cuff or deltoid may require the resistance to be applied through the lateral aspect of the scapula rather than through the arm.

FIGURE 6. Horizontal adduction measure of posterior shoulder tightness. The patient is first asked to actively retract the scapula. The tester than manually stabilizes the scapula while passive horizontal adduction is measured.

Posterior shoulder tightness (capsular or rotator cuff) has been associated with excessive protraction of the scapula[52] and may contribute to scapular dyskinesis.[17] Two common methods of assessing posterior shoulder tightness are: internal rotation at a 90-degree abduction[53,54] and spinal level reached with reaching behind the back.[55] These 2 methods have demonstrated acceptable levels reliability for clinical use. Gerber et al[56] showed that different parts of the posterior capsule restrict internal rotation with the arm by the side versus 90 degrees. Therefore, authors have recommended that clinicians use both assessment methods to allow for a more comprehensive assessment of posterior shoulder tightness.[57] Measurements of shoulder internal rotation are affected by humeral and glenoid version and therefore make it difficult to distinguish between soft-tissue tightness and bony alterations causing diminished internal rotation. To overcome this problem, Laudner et al[52] have described measuring horizontal adduction with the arm at 90-degree elevation and the scapular blocked with satisfactory reliability (Fig. 6).

TREATMENT

As suggested by Tate et al,[22] scapular dyskinesis can be multifactorial and the dyskinesis may be either a cause or the result of pathology, so it is important to evaluate and address each patient's specific impairments. Once key impairments are identified, appropriate treatment strategies can be used. Treatment typically includes strengthening and training neuromuscular control, stretching including manual techniques to the shoulder and spine, and sometimes the use of taping or bracing.

STRENGTHENING

Both the glenohumeral musculature and the scapulothoracic musculature should be addressed for scapular dyskinesis. Strong evidence exists that strengthening is an effective treatment for shoulder pathology including shoulder impingement[58] and shoulder instability.[59]

It is important to consider both the current level of strength and the level of motor control to prescribe the correct mode and dosage of exercise. This is especially important in patients with well-developed musculature, but poor scapular control.[25] Different exercises have been identified to activate specific scapular muscles at specific levels of electromyographic activity.[60–71] It is important to visually observe the patient to maintain correct scapular kinematics and to specifically target the intended muscle groups. Failure to do so could lead to excessive glenohumeral tissue stress and reinforce poor motor control patterns.[72]

Strengthening exercises should begin in a protected low-range or mid-range position with the arm supported and progress to end-range positions that work against the resistance of gravity and further external resistance (Fig. 7). Exercise should be progressed based on simple variables such as amplitude of muscle activity (repetitions and resistance), as well as more complex variables such as speed and complexity of movement (body and joint position and timing of muscular activation).[35,41,73] The healing properties of the tissues involved and the patient's ability to control the scapula must also be considered in progression.[25] Specifically for scapular dyskinesis, care should be taken to prescribe exercises that facilitate the lower and middle trapezius rather than the upper trapezius to avoid premature elevation of the scapula during shoulder elevation and to balance the force couple between the serratus anterior, upper trapezius and lower trapezius during upward rotation of the scapula.

In addition, incorporating hip and trunk movements during functional activities can further challenge the scapular muscles.[19,74] A study by Cools et al[75] demonstrated that contralateral single-limb stance during dynamic pulling exercises significantly increased the activity of the lower trapezius. This suggests that lower extremity position and motions are able to affect shoulder muscle activation through the kinetic chain.[75] Another example can be using a single leg stance or a half-kneeling while performing a chop and lift movement.[76] Some common exercises are shown in Figure 7.

STRETCHING

Based upon the examination, any posterior shoulder tightness should be addressed first before initiating a glenohumeral strengthening program as this may affect scapular kinematics.[77,78] Self-stretching including cross body adduction, "sleeper," and towel internal rotation stretching have been advocated to improve internal rotation mobility. A randomized controlled trial by McClure et al[57] demonstrated that in healthy subjects with internal rotation deficit, the cross body adduction stretch resulted in significant improvement over controls and the "sleeper" stretch did not (Fig. 8).

Pectoralis tightness and thoracic flexion have been shown to limit shoulder elevation range of motion and scapular kinematics.[39,79] Borstad and Ludwig[80] have demonstrated the unilateral corner stretch is the most effective at elongating pectoralis minor, followed by the supine manual stretch with a towel placed longitudinally along the spine.

MANIPULATION/MOBILIZATION

Poor posture has a strong effect on shoulder mobility[40,79] and is a common finding in patients with scapular dyskinesis. It has been proposed that poor posture can lead to inhibition of the postural musculature and clinically the lower trapezius may be the most difficult muscles to reeducate and strengthen.[81] In addition, anecdotal reports

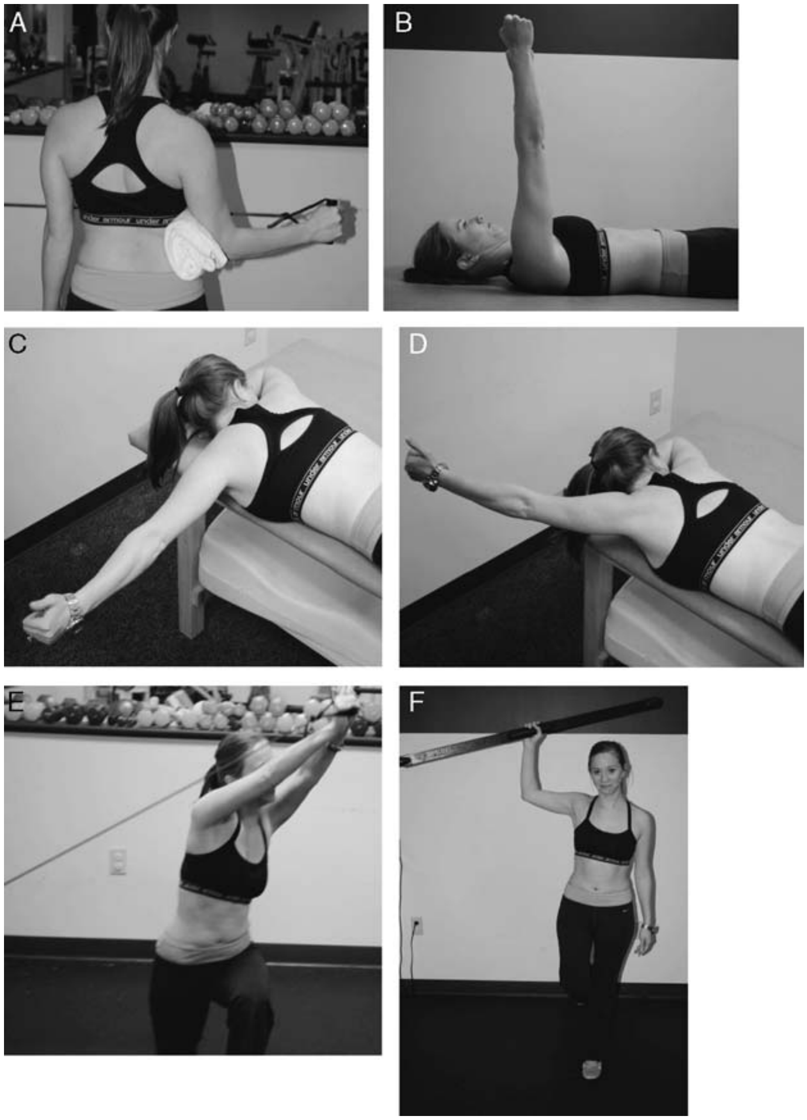

FIGURE 7. Common scapular strengthening exercises of varying difficulty. Low level: (A) external rotation with scapula stable; (B) ceiling punch for serratus anterior. Moderate level: (C) "prone T" for middle trapezius; (D) "prone Y" for lower trapezius. High level: (E) half-knee diagonal lift; (F) single leg stance and body blade with elevation.

suggest that increased thoracic kyphosis is directly associated with lower trapezius inhibition.[82] It has also been reported that muscle inhibition can be a result of an inflamed or injured joint.[83–85] Recently, Muth et al[86] reported a 26% increase in isometric elevation strength immediately after thoracic manipulation in subjects with signs of shoulder impingement.

Mobilization/manipulation techniques including supine and prone posterior to anterior glides as described by Flynn,[87] and seated thoracic extension mobilization, and reverse natural apophyseal glides as described by Mulligan[88] can be used both to improve thoracic extension mobility[89] and for facilitation of the lower trapezius (Fig. 9).[81] Postoperatively or in patients with tight periscapular musculature, manual gliding techniques in a superior, inferior, medial, or lateral direction and/or scapular distraction techniques may be indicated to improve scapular mobility.

NEUROMUSCULAR RE-EDUCATION

Exercises to retrain the orientation and kinematics of the scapula are often prescribed by physical therapists.[90] Peripheral neuromuscular facilitation techniques may be used early in the rehabilitation process to promote isolated scapular movements, even in postoperative conditions. Mottram et al[91] used a motion analysis system and surface electromyography to demonstrate that it is possible for healthy subjects to learn and accurately repeat scapular movement without guidance. The technique used involved shoulder elevation in the plane of the scapula.[91] As a modification of this technique for those patients who are not yet able to successfully control the scapula through unassisted range of motion, we have used a "wall slide" technique where the patient places the forearms on a wall in neutral with elbows flexed and arm in the plane of the scapula (Fig. 10). The patient is then instructed to slide the

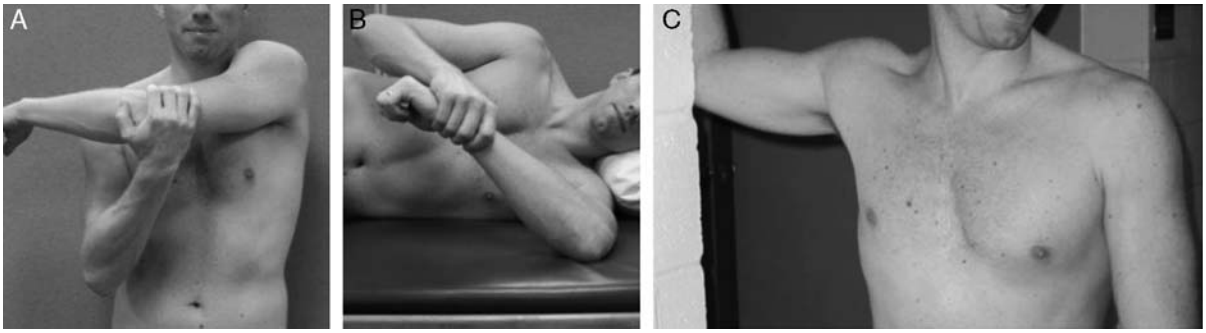

FIGURE 8. Stretching for (A and B) posterior shoulder tightness and (C) pectoralis minor. The end-range position is typically held for 30 seconds.

forearms up the wall and lower with control. In this method, the wall acts to decrease gravitational pull on the upper extremities and provide some scapular protraction feedback during the movement.

TAPING AND BRACING

Taping and bracing can be considered as an adjunctive intervention in patients whose symptoms are reduced with either postural correction or the scapula reposition test. Two case studies have demonstrated use of the scapular repositioning test to determine a change in symptoms before taping.[92,93] These case studies provided examples of taping as effective in symptom reduction as part of a comprehensive program. Also, taping has been shown to alter EMG activity in the scapular musculature of symptomatic swimmers[94] and professional violinists.[95] Taping has been shown to be effective in reducing thoracic kyphosis,[46,96] as well as improving pain-free shoulder elevation range of motion.[96] Furthermore, correction of posture has been shown to both increase shoulder elevation range of motion and elevation force at 90 degrees.[36] Thus, it is logical to believe scapular taping may be an effective adjunctive intervention to facilitate scapular control and decrease pain with shoulder elevation. The proposed mechanisms of action of scapular taping include provision of a low-load, long duration stretch to the anterior musculature, improved scapular alignment, increased subacromial space,[25] reduced tension in the subacromial tissues,[92] improved proprioception,[97] and improvement of joint positional faults.[88]

FIGURE 9. Thoracic spine extension mobilization. The therapist cradles the patient's arms and uses the hypothenar area on the spinous process as a fulcrum to encourage thoracic extension.

Taping should be considered for patients that respond well to the scapular repositioning test or postural correction and have difficulty maintaining optimal posture or require manual facilitation of correct movement patterns. Although various methods have been described, we prefer a modification of the postural taping technique as described by Greig et al.[96] The tape may be applied unilaterally or bilaterally, although we prefer bilateral taping to enhance thoracic spine extension (Fig. 11).

FIGURE 10. Wall slide exercise.

FIGURE 11. Scapular taping. The patient is asked to sit "tall and erect" to slightly extend the thoracic spine and also asked to hold moderate scapular retraction. The white cover roll stretch (Beiersdorf-Jobst Inc.) is applied first, without tension, beginning just anterior to the acromion and acromioclavicular joint and angling across the inferior angle of the scapula crossing the spine at approximately T8-9. The brown leukotape (Beiersdorf-Jobst Inc.) is then anchored anteriorly over the white tape and held firmly by the examiners thumb while the tape is pulled firmly diagonally down and across the inferior angle of the scapula to the contralateral thorax over the cover roll stretch. It is helpful to instruct another person how to remove the tape by gently lifting the edge of the tape and carefully pressing down on the skin to detach it. Patients should not remove their own tape.

If taping is effective for the patient, but they require more than a few applications to attain a long-term benefit or have sensitivity or allergy to adhesives, the S3 Spine and Scapula Stabilizing brace (Alignmed Inc., Santa Ana, CA) is a useful alternative. The S3 brace works in a similar manner as taping, but without the adhesive and, therefore, can be worn over longer periods of time. Anecdotally, these authors have had good results with use of the S3 brace with patients with scapular dyskinesis and with poor posture, but further research is needed to determine generalizability.

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