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Exercise Modifications and Strategies to Enhance Shoulder Function

Peter Ronai, MS, CSCS, RCEP
Ahlbin Rehabilitation Centers, Bridgeport, Connecticut

summary

The purposes of this article are to identify exercise performance–related factors that may contribute to shoulder pain and dysfunction and to describe appropriate training strategies for promoting shoulder stability and enhanced function. This article is not intended to help the reader diagnose and treat injuries or prescribe therapeutic interventions. Strength and conditioning professionals should encourage injured clients to consult a physician, physical therapist, or other appropriate health care professional before starting a conditioning program.

Strength and conditioning professionals occasionally face the challenges of working with previously injured clients. It is not uncommon to work with individuals who have experienced either sudden, short-term (acute) or chronic (lasting weeks or months) shoulder pain. Although these individuals may engage in cardiovascular exercise and strength training of uninjured areas, they should seek medical attention and receive clearance before they start strength training their previously injured area (shoulder). Strength and conditioning professionals should address upper extremity exercise only after their clients have received medical clearance to begin training. Physicians and physical therapists may provide specific suggestions and parameters for their clients. These suggestions should be incorporated into future shoulder exercise training. Rotator cuff tendonitis and impingements are specific shoulder disorders that clients may be recovering from. Rotator cuff tendonitis and impingement are caused by a number of factors, some of which include "microinstability" (1, 12, 24, 25), sudden trauma (12, 24), repetitive trauma or overuse (1, 12, 24, 25), variations in anatomical structure such as a Type II or III acromion process (hook-shaped projection of the lower surface of the acromion process) (1, 8, 25), degenerative changes of the humeral head, subacromial surface or thickening of the subacromial bursa (8, 12, 25, 37), shoulder capsular tightness (9, 12, 21, 31), and improper posture and scapular positioning (4, 9, 13, 14, 19, 23). Strength and conditioning professionals who train injured clients without medical clearance can cause them further injury and may be held liable. After successfully completing physical therapy, many of these individuals benefit from postrehabilitation conditioning and, in some instances, specific exercise technique modifications (7, 9, 10, 15, 17, 18, 20, 24, 25, 26, 36, 37). Shoulder pain can make self-care activities such as brushing teeth, combing hair, putting on a jacket, and sleeping through the night very painful and sometimes impossible. Regaining the ability to do these activities without pain may also be an important prerequisite before your client returns to the gym. Strength and conditioning professionals can help their medically cleared clients incorporate proper exercise technique(s) and help them improve their shoulder stability and flexibility.

Shoulder Pain Defined

Chronic shoulder pain is the most frequently experienced upper extremity problem in recreational and professional athletes (1). Common injuries and conditions such as rotator cuff impingements, tendonitis, and tears occur most frequently in individuals over 40 years of age (37). They are most prevalent in individuals performing repetitive overhead work (1).

Structure

The primary role of the shoulder is to place the upper extremity in a position that allows the hand to function (26). Unlike the sturdy, deep hip joint, the shoulder is a shallow ball-and-socket joint that relies on the interaction of several passive and dynamic factors for its stability. These factors provide the right blend of stability and mobility. The glenoid fossa (shoulder socket), located on the anterolateral surface of the scapula (shoulder blade), is only one-third the size of the humeral head (8, 22, 31; see Figure 1). Found within the glenohumeral joint capsule is a stabilizing ring known as the glenoid labrum. The glenoid labrum, a fibrocartilaginous ring, attaches to the rim of the glenoid fossa, thereby deepening the shoulder socket and improving shoulder stability. Removal of the labrum has been shown to reduce shoulder joint stability by 20% in cadaveric shoulders (8). A fibrous, hammocklike capsule and a series of ligaments secure the humeral head within the glenoid fossa and contribute most to "end range" joint stability (8, 22, 31). Negative intra-articular pressure also contributes to shoulder joint stability (22). The capsule is basically loose in "mid-range" where the shoulder joint relies most on active stabilization from muscles (8, 22, 31). Four relatively small muscles known as the rotator cuff collectively compress, depress, stabilize, and steer the humeral head within the glenoid fossa during various arm movements (8, 22, 31, 35; see Table 1). The long head of the biceps also contributes to shoulder joint stability during overhead motion (23). The overall structural arrangement of the shoulder contributes to its mobile and relatively unstable status (1, 8, 12, 22, 31, 35). The scapula provides a mobile yet stable base (platform) for the humeral head (ball-shaped portion of the humerus) to rotate on during arm motions (6, 8, 9, 11, 19, 21, 22, 25, 27, 30, 31, 35). The humeral head is approximately two-thirds larger than the glenoid fossa, yet it is generally constrained within 1–2 mm of the center of the glenoid fossa throughout most of the arm range of motion (22, 31, 35). Specific scapular motions against the thorax (8, 9, 13, 19, 21, 26) accompany each humeral (arm) movement within the glenohumeral (shoulder) joint (see Table 2; see Figures 2a and 2b for specific muscular force couples). These motions provide a stable base from which the 4 rotator cuff muscles function and help maintain optimal rotator cuff and deltoid muscle length tension (8, 22, 31, 35). Proper posture (9, 13, 14, 19, 23, 36) and good rotator cuff and periscapular muscle strength (12, 35, 37) can all contribute to sound shoulder function and stability. Two articulations, the sternoclavicular and acromioclavicular joints, enable the scapula to accompany the humerus during its motions and to provide the scapula with synchronous support (6, 11, 27).

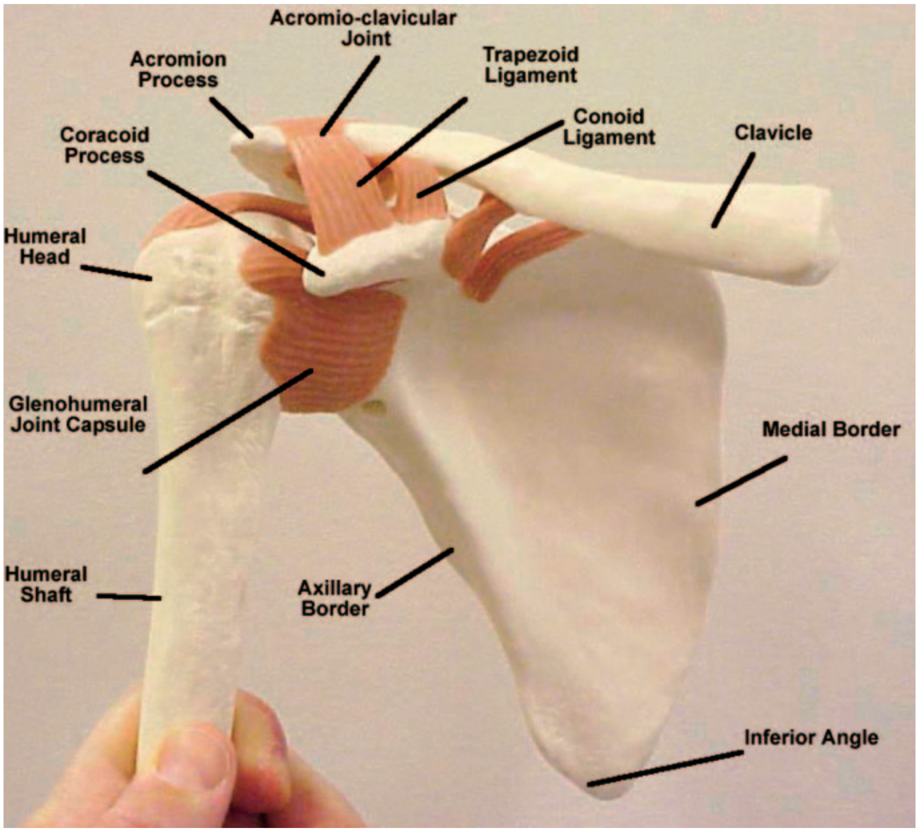

Figure 1. Anterior view of the scapula.

Function

Complex arm and shoulder motions require an intricate balance of scapulothoracic (scapular motion on the rib cage) and glenohumeral (shoulder joint) movements. The healthy humerus can perform approximately 180 degrees of flexion and abduction. During abduction, scapular upward rotation contributes to approximately 60 degrees of this elevation (6, 27). Some authors (5, 6, 11, 21, 22, 25, 26, 31, 35) have described the relationship between the scapula and humerus during shoulder elevation as "Scapulohumeral Rhythm."

Table 1
Summary of Attachments and Functions of Rotator Cuff Muscles

Muscle	Attachments	Action(s)
Supraspinatus	Supraspinous/ Fossa of the scapula Upper facet of greater tuberosity of the humerus	Abduction Compression and depression of humeral head during elevation
Infraspinatus	Infraspinous fossa of the scapula Middle facet of the greater tuberosity of the humerus	External rotation Compression and depression of humeral head during elevation
Teres minor	Inferior medial border of the scapula Lower facet of the greater tuberosity of the humerus	External rotation Compression and depression of humeral head during elevation
Subscapularis	Subscapular fossa of the scapula Lesser tuberosity of the humerus	Internal rotation Compression and depression of humeral head during elevation
Biceps brachi long head (participates with the rotator cuff)	Supraglenoid tubercle Radial tuberosity Fibrous lacertus (ulna)	Flexion and abduction Compression of humeral head during elevation

The scapula upwardly rotates approximately 1 degree for every 2 degrees of glenohumeral abduction (8, 11, 14, 19, 21, 27, 31, 35). The scapula performs upward rotation during glenohumeral abduction (5, 6, 8, 9, 21, 27) and tilts posteriorly (1, 5, 6, 9, 13, 19, 26, 27) against the rib cage during glenohumeral flexion. These scapulothoracic actions are facilitated by a series of motions at the sternoclavicular and acromioclavicular joints (6, 27). Sternoclavicular joint rotation (on its axis), elevation, depression, protraction, and retraction accompany scapular tilt, elevation, depression, protraction, and retraction, respectively. The acromioclavicular joint, an articulation between the distal lateral end of the clavicle and the acromion process (lateral hoodlike projection of the scapula), contributes to scapular winging, tilting, and upward rotation (6, 27). The sternoclavicular joint contributes 40 degrees and the acromioclavicular joint contributes another 20 degrees to the total 60 degrees of scapular upward rotation during glenohumeral abduction (6, 27). Failure of the scapula to fully rotate upward can prevent the acromion process from rotating out of the way of the humeral head as it elevates. This can contribute to mechanical compression of the humeral head, rotator cuff tendons, and subacromial bursa against the undersurface of the acromion process (1, 5, 12, 13, 24). This compression is called "subacromial impingement." Injuries to the sternoclavicular and acromioclavicular joints can also hinder shoulder function, but a full discussion of these injuries is beyond the scope of this article. Some of the other factors that can contribute to impingement include subacromial bone spurs and hook-like morphology (1, 8, 25); arthritic changes to the humeral head (12, 25), glenoid fossa, or subacromial surface (25); bursal thickening (25); and rotator cuff or scapular stabilizer muscle weakness or fatigue (12, 35, 37). Kyphotic thoracic spine posture (forward rounded shoulders and upper back), a forward head, and scapular instability secondary to periscapular muscle weakness can prevent the scapula from moving properly on the thorax (4, 9, 13, 14, 19, 23, 30, 37). According to Voight and Thompson (35), scapular instability is found in 68% of individuals with rotator cuff problems and 100% of individuals with glenohumeral instability problems. A tight or adhesive glenohumeral joint capsule and weak rotator cuff muscles can prevent the humeral head from rotating properly on the glenoid fossa during elevation (9, 12, 21, 33, 35, 37). This can cause the humeral head to migrate upwards against the undersurface of the acromion pro-cess (1, 5, 9, 12, 13).

Subacromial Impingement

Synchronous and unimpeded shoulder joint motion is a by-product of proper scapular motion along the thorax (8, 9,

Table 2
Glenohumeral and Accommodating Scapular Force Couples and Motions

Glenohumeral motion	Glenohumeral muscles	Scapular motion	Periscapular muscles
Abduction	Deltoid/Supraspinatus Initiate abduction Subscapularis, infraspinatus, and teres minor compress and depress humeral head	Upward rotation	Upper and lower trapezius and serratus anterior
Adduction	Latissimus dorsi Teres major Pectoralis major Subscapularis, Infraspinatus, and teres minor stabilize humeral head	Downward rotation Depression	Pectoralis minor Rhomboids Levator scapula Lower trapezius
Flexion	Anterior/Medial deltoid Clavicular pectoralis Supraspinatus Long head of biceps brachi Coracobrachialis Infraspinatus, teres minor, and subscapularis stabilize humeral head	Posterior tilt	Serratus anterior Upper and lower trapezius
Extension	Latissimus dorsi Teres major Sternal pectoralis Long head of triceps brachi Posterior deltoid Infraspinatus, teres minor, and subscapularis stabilize humeral head	Anterior tilt Downward rotation Depression	Pectoralis minor Pectoralis minor, rhomboids, levator scapula Pectoralis minor Lower trapezius Serratus anterior
Horizontal flexion Internal rotation	Pectoralis major Subscapularis	Protraction	Serratus anterior
Horizontal extension External rotation	Posterior deltoid, infraspinatus, teres minor Infraspinatus, teres minor	Retraction	Mid trapezius Rhomboids

13, 19, 21, 26), balanced muscle strength and function, efficient timing of synergistic muscle contractions (14, 15, 21, 22, 25, 26, 35, 36), capsular flexibility (9, 12, 21, 33, 37), proper posture (4, 9, 13, 14, 19, 23, 36), and sensorimotor integration (neuromuscular coordination) (14, 15, 23, 26, 34). The deltoid muscle's line of force pulls the humeral head upwards toward the subacromial surface during abduction. The supraspinatus creates a more medially directed line of pull toward the glenoid fossa. The remaining rotator cuff muscles assist the supraspinatus by compressing and depressing the humeral head. This "force couple," as it is known, helps prevent subacromial impingement in a normally functioning shoulder (21, 22, 25, 26, 35, 36). If the rotator cuff muscles fatigue before the larger deltoid fatigues or if there is an imbalance in torque production between the rotator cuff muscles and the deltoid, subacromial impingement can occur. Previously mentioned factors such as variations in acromion process anatomy (1,5, 8), degenerative changes of the humeral head and subacromial surface and thickening of the subacromial bursa (8, 12, 25, 37), glenohumeral capsular tightness (9, 12, 21, 31), and poor posture (4, 9, 13, 14, 19, 23) can reduce the subacromial space (the area between the bottom of the acromion process and the top of the humeral head). The subacromial space is normally between 5 and 10 mm in size (25). A reduction in the size of the subacromial space can precipitate impingement. Ordinarily, in an open chain, when the arm flexes or abducts, the convex humeral head should roll upward on the concave glenoid fossa (socket) and then spin and glide down-

Figure 2. (a) Scapular force couples during glenohumeral abduction. Moving counterclockwise from the left, each arrow represents the actions of the lower trapezius, serratus anterior, and upper trapezius during upward scapular rotation. (b) Scapular force couples during glenohumeral flexion. Moving counterclockwise from the bottom left, each arrow represents the actions of the lower trapezius, serratus anterior, and upper trapezius during posterior scapular tilt.

Figure 3. Scapular depression with the seated press-down exercise.

ward to avoid hitting the subacromial surface (8, 25). This spinning and downward gliding motion also helps prevent the greater tuberosity (anterior and lateral projection on the humeral head and site of attachment of the supraspinatus muscle) from being compressed against the subacromial surface (8, 25). During subacromial impingement, the humeral head and greater tuberosity translate superiorly and strike the subacromial surface, compressing the rotator cuff and biceps brachi long head tendons and subacromial bursa (a fluid-filled lubricating sac) (1, 13, 24). This can cause shoulder pain and sensitivity. Subacromial impingement can be avoided if the scapula moves properly on the thorax and the rotator cuff muscles stabilize the humeral head (8, 25). McCluskey and Getz (22) have described the contributions of the rotator cuff and biceps brachi muscles to this downward humeral head motion. As previously mentioned, mechanical narrowing from bone spurs, osteophytes, a thickened bursa, and an irregularly shaped acromion process (Type II, III, or hooked acromion) are a few causes of primary impingement. Muscular weakness, torque generating capacity imbalances between the rotator cuff and the deltoid muscles, poor posture, and joint capsule tightness or adhesive capsulitis are a few examples of secondary impingement. In addition, improper exercise technique and inappropriate overuse of certain exercises can all contribute to shoulder impingement and discomfort (7, 17, 18, 25, 36). Most strength and conditioning specialists are not qualified to diagnose or treat these problems; however, a basic understanding of shoulder function and pathomechanics can help them and their clients make better-informed exercise choices. As previously mentioned, trainers should follow all guidelines supplied by clients' physicians or physical therapists. Clients experiencing recurring pain should be sent back to their physician or therapist.

Other Factors Contributing to Shoulder Stability and Normal Function

Five periscapular muscles, including the serratus anterior, pectoralis minor, levator scapula, rhomboids, and trapezius

Figure 4. Wall push exercise. Press shoulders down and push into the wall.

(all 3 segments), contribute collectively to scapular stability. The serratus anterior and trapezius muscles cause upward rotation during glenohumeral abduction and posterior scapular tilt during glenohumeral flexion. They create essential force couples that enable the scapula to rotate on the thorax (6, 21, 22, 26, 27, 35, 36) (see Figures 2a and 2b.). The pectoralis minor, levator scapula, and rhomboids cause downward scapular rotation that accompanies glenohumeral adduction, as well as the anterior scapular tilt that accompanies glenohumeral extension.

Essential Principles and Strategies

A sound shoulder stability exercise program should emphasize improving strength and endurance of periscapular and rotator cuff muscles, encouraging good posture, maintaining adequate flexibility of musculotendinous and capsular tissues, and reinforcing proper execution of all exercises. Clients experiencing pain during or after exercise sessions should be referred to their physician. The following principles can contribute to optimizing shoulder function and pain-free motion. The scapula must function as a stable platform for the humeral head. The scapulothoracic articulation is the most proximal component of this platform. Strength and conditioning specialists should include exercises that help develop this proximal (scapular) stability in their clients' programs. Important periscapular muscles include the pectoralis minor, serratus anterior, trapezius (all 3 segments), levator scapula, and rhomboids. The serratus anterior and trapezius (upper and lower segments) muscles in particular contribute extensively to scapular upward rotation and posterior tilt. Closed-chain exercises (where the hand is fixed to the supporting surface) such as seat-

Figure 5. (a) Bottom position of push-up with a plus. Limit glenohumeral extension during descent. (b) Top position of push-up with a plus. Protract both scapula on top.

Figure 6. Internal rotation with exercise bands.

Figure 7. External rotation with exercise bands.

Table 3
Exercise Modification Strategies

Exercise	Modification
Bench press	Limit depth of descent of bar and arm with a rolled towel on the sternum. Keep arms below shoulder height.
Military press	Use dumbbells, keep arms in scapular plane. Limit descent of weight, keeping weights at ear level (90° elbow bend).
Latissimus pull-down	Keep grip within shoulder width with arms in the scapular plane. Pull the bar down toward the chest.
Squat with low bar placement	Perform front squats to avoid placing the shoulders in stressful position.
Rowing	Limit shoulder extension. Do not let the elbow pass the back of the rib cage. Do not hyperextend the humerus (shoulder).
Lateral dumbbell raises	Avoid the "empty can" position by keeping thumbs up and arms slightly in front of the body in the scapular plane.
Supine triceps extensions	Perform standing tricep push-downs. Keep sternum up and lower tips of scapula (inferior angles) posteriorly tilted (down and in against the rib cage).

ed press-ups (scapular depression), wall pushes (scapular posterior tilt and depression), and push-ups with a plus (see Figures 3, 4, 5a, 5b) can improve shoulder stability, proprioception, and sensorimotor control (3, 14, 15, 21, 23, 26, 34–37). Performing these exercises on soft or unsteady surfaces, such as stability balls and mats, can further address sensorimotor control. Clients should also perform specific rotator cuff strengthening exercises, such as internal and external rotation, from a neutral position (arm at side with elbow flexed 90 degrees) and/or with the glenohumeral joint in the scapular plane (1, 12, 22, 25, 35, 37) (see Figures 6–7). Placing a towel between the arm and body during internal and external rotation exercises can decrease deltoid activity, relax the supraspinatus tendon, and decrease pain (25, 37). The "empty can" (abduction with internal rotation) position can inflame a painful shoulder by reducing the subacromial space, placing the humerus in an impingement position, and compressing the rotator cuff tendons in abduction (4, 7, 16, 20, 25, 36, 37). Substituting the "full can" (abduction with external rotation, in the plane of the scapula) can prevent subacromial space narrowing and impingement. Glenohumeral external rotation opens the subacromial space and prevents compression of the greater tubercle against the subacromial surface (4, 20, 21, 25, 26, 30). Exercises such as the behind-the-neck press and behind-the-neck lat pull-down place the arm in abduction with extreme external rotation and some horizontal abduction. This positioning increases stress in the joint capsule, ligaments, and rotator cuff tendons and may cause shoulder discomfort (7). This position is contraindicated in unstable shoulders (4, 7, 16, 18, 20, 25, 36, 37). Placing the arm in the plane of the scapula (approximately 30 degrees in front of the thorax) during overhead activities increases the subacromial space, reduces stress in capsuloligamentous tissues and tendons, and contributes to normal scapulohumeral rhythm (4, 7, 10, 16, 20, 25, 36, 37). Some additional exercises that can be stressful to the shoulder (primarily anterior capsule, ligaments, and rotator cuff tendons) include wide and upright rowing (placing the arms too high, out too wide, and pulling the elbows too far behind the body) (17); bench press (elbows placed at or above shoulder height and allowing elbows and shoulders to extend below thorax during descent); and heavy, low-bar placement squats. Each of these exercise techniques can place the glenohumeral joint in a stressful position (7, 17). Exercises causing pain should be eliminated (4, 7, 17, 18, 20, 21, 25, 29, 36, 37) (see Table 3). Periscapular (previously mentioned closed-chain activities) and rotator cuff exercises should be done 2–3 times per week at either the later part of the warm-up (after tissues are sufficiently warm) or the cool-down phase. The periscapular muscles can be strengthened with open-chain activities as well (36, 37). Three sets of 15–20 repetitions will help address improvements in muscular endurance (2). If time permits, these exercises can be done on their own day instead of being integrated into another workout. These exercises are meant to improve endurance of stabilizing muscles, not to build power. Proper technique and muscular control should be possible with every repetition.

Compound exercises such as rows and reverse flys (horizontal abduction) emphasize synchronized activity between the periscapular and rotator cuff muscles (3, 4, 10, 12, 21, 25, 32, 36, 37) and can be a part of an upper back and shoulder workout. These exercises should be done twice a week, and the overall volume should reflect the goals of the client's periodized program (2). Proper form must be reinforced and executed. Clients involved in sports may find additional closed-chain activities such as push-ups with single arm support and stability ball push-ups (see Figures 8 and 9) an appropriate challenge because they increase joint compressive forces, challenge balance and proprioception (position sense), and also improve stability (4, 14–16, 21–23, 34, 36, 37). The degree of difficulty of exercises like these can be gradually increased by changing exercise surfaces and equipment, speed, direction, and number of repetitions. They can be integrated into the scapular stability workout days and should initially be done in multiple sets (2–3) of low repetitions (3–5) because they can be diffi-

Figure 8. Single arm support .This should be performed at the top position after completing a push-up.

Figure 9. Middle position during a stability ball push-up.

Figure 10. Inferior capsule stretch. Support arm while applying a gentle, pain-free stretch.

Figure 11. Posterior capsule stretch. Support arm while applying a gentle, pain-free stretch.

cult in the beginning. Numerous authors emphasize the importance of using good posture when performing shoulder exercises (1, 4, 6, 9, 13, 17, 19, 27, 28, 30, 34, 36). Optimal flexibility of the inferior and posterior joint capsule enables the humeral head to roll and spin properly against the glenoid fossa during abduction and flexion. As previously mentioned, a tight or adhesive capsule can interfere with proper humeral rotation and can contribute to upward migration of the humeral head beneath the acromion process (impingement). Develop optimal flexibility in the inferior and posterior capsule with pain-free stretches (see Table 3; see Figures 10 and 11). Capsule stretches can be done daily and should occur after performing a light, 5–10 minute warm-up or at the end of a general exercise session. During each stretch, gently apply light pressure until a comfortable stretch is felt. Use the opposite hand to support the arm being stretched and hold this position for 20–30 seconds. The prestretching warm-up can consist of 5–10 minutes of low-level aerobic activity such as brisk walking or stationary cycling (1, 4, 9, 12, 21, 33, 36, 37).

Conclusion

Exercise-related shoulder pain is common in individuals over the age of 40 (37). It can result from a combination of factors such as scapular instability, periscapular and rotator cuff muscle weakness, poor posture, capsular tightness, improper exercise technique, anatomical variants, degenerative changes, swelling and joint space narrowing, adhesive capsulitis, and overuse. A conditioning program that emphasizes restoration of strength and flexibility of stabilizing structures can help enhance shoulder function. Strength and conditioning professionals occasionally work with previously injured clients who have been medically cleared to return to exercising. Strength and conditioning professionals must follow all recommendations made by their clients' physicians and physical therapists. Pain serves as a red flag and warrants intervention from a medical professional. Other interventions, including improving postural awareness, modifying exercise techniques, and redesigning exercise programs, may also be warranted. Improving clients' understanding of this process may facilitate their return to their regular exercise activities. ♦

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Ronai

Peter Ronai is a clinical exercise physiologist and supervisor at the Ahlbin Rehabilitation Centers of Bridgeport Hospital in Shelton, Connecticut. He is also an adjunct professor in the graduate Exercise Science Department at Southern Connecticut State University.