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Article *in* Current Reviews in Musculoskeletal Medicine · October 2017
DOI: 10.1007/s12178-017-9449-9

Curr Rev Musculoskelet Med
https://doi.org/10.1007/s12178-017-9449-9

Current Concepts in Rehabilitation for Traumatic Anterior Shoulder Instability

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Abstract

Purpose of review The objectives of this review are to evaluate the current evidence-based literature and concepts surrounding rehabilitation in patients with anterior shoulder instability injuries and surgical repair.

Recent findings The current literature evidence for shoulder rehabilitation for anterior shoulder instability and labral repair is limited. As a result, there are variations among surgeons and physical therapists in rehabilitation protocols after anterior shoulder instability injuries and repair. While general consensus on certain rehabilitation parameters exists, the evidence for the importance of rehabilitation and functional performance test for return to sport in future injury prevention is still lacking in literature.

Summary Rehabilitation after anterior shoulder instability injury and anterior labral repair is paramount in the injured or post-operative shoulder. Restoration of soft tissue mobility, dynamic glenohumeral joint stability, and balance and strength around the shoulder not only protect healing of injured or repaired soft tissues but also potentially minimizes future re-injury or recurrence risk.

Keywords Anterior shoulder instability · Shoulder labral tear · Bankart tear · Rehabilitation · Return to sport · Exercise

Introduction

The glenohumeral joint is the most commonly dislocated diarthrodial joint in the human body [1]. The maintenance of glenohumeral stability is a complex interplay between both static and dynamic factors. Optimization of the dynamic structures around the glenohumeral joint is integral for restoring stability to both non-operatively treated and surgically stabilized shoulders following anterior instability injury. An appropriate rehabilitation program therefore plays a vital role in the successful outcome following an episode of anterior shoulder dislocation and following surgical repair. The objectives of this article are to (1) review the current evidence and concepts surrounding rehabilitation in anterior shoulder instability injuries and repair; (2) provide our institution's rehabilitation protocol and return to sport functional assessment and performance test following surgery; and (3) identify areas for future work in anterior shoulder instability rehabilitation.

Anatomy, Biomechanics, and Rationale for Rehabilitation After Anterior Glenohumeral Instability

The glenohumeral joint permits a wide range of motion and is the most mobile diarthrodial joint. It is inherently unstable due to the bony proportion of a relatively small glenoid surface and large humeral head. As a result, shoulder stability is

This article is part of the Topical Collection on *Management of Anterior Shoulder Instability*

Electronic supplementary material The online version of this article (https://doi.org/10.1007/s12178-017-9449-9) contains supplementary material, which is available to authorized users.

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Published online: 16 October 2017

mostly conferred from its soft tissue structures. For the purpose of discussion and simplification, it is useful to categorize the soft tissue stabilizers as static (i.e., labrum, glenohumeral ligament) or dynamic stabilizers (i.e., musculotendinous structures such as rotator cuff, deltoid, biceps, pectoralis major, and latissimus dorsi). These static and dynamic stabilizers function in a coordinated fashion to provide range of motion while balance the shoulder for function and stability.

Muscle weakness and/or imbalance of dynamic stabilizers could lead to recurrent anterior instability both after injury and surgical repair. Individuals with persistent rotator cuff weakness may be more susceptible to recurrent anterior shoulder instability. Edouard et al. reported that deficits in internal and external rotations shoulder strength resulting in an imbalance of the forces were associated with recurrent anterior shoulder instability [2]. Individuals with recurrent anterior instability had significant deficits in both internal and external rotator peak torque at 180 and 120°/s [2]. Similar associations between rotator cuff deficits, in particular internal rotation deficits have been linked to recurrent anterior shoulder instability [3–5]. In addition to deficits in dynamic shoulder muscular restraints, disruption to the shoulder sensorimotor system has also been implicated in recurrent anterior instability [6]. Rehabilitation to reconstitute and optimize shoulder dynamic strength and sensorimotor function is therefore important to minimize recurrent risk after an anterior instability event or surgical repair.

Rehabilitation After Traumatic Anterior Instability Injury

The majority of individuals who have a first-time anterior shoulder dislocation are treated non-operatively, although there is a growing trend to consider surgical management in younger patients (age < 30) and high-risk individuals such as contact athletes. In these high-risk individuals, early surgical stabilization will help prevent recurrence and further damage to the soft tissue, cartilage, and glenoid bone. In the older lower-risk patients, the goals of rehabilitation after anterior shoulder instability are to restore pain-free range of motion and shoulder muscle strength and control. Factors to consider in rehabilitation of individuals with a traumatic anterior shoulder dislocation includes (1) onset of injury; (2) degree of instability; (3) frequency and number of dislocations; (4) concomitant injuries; and (5) premorbid activity level.

Acute Phase After Injury—Phase I

Patients following a traumatic anterior shoulder dislocation event will typically present with pain, muscle spasms, and will guard the arm in an internally rotated position resting on the side of the body. They will likely self-limit their own activity level on the injured side to protect the shoulder. Therefore, the goals of the initial phase of after a significant instability event are to: (1) reduce pain, inflammation, and muscle guarding; (2) protect healing of soft tissues and minimize further injury to the joint capsule; (3) minimize the negative effects of immobilization; (4) and reestablish dynamic joint stability and proprioception. Typically, this involves a period of immobilization to reduce pain. The length of time in a sling or arm position of immobilization after an anterior shoulder dislocation have not been clearly established as having an effect on recurrent instability risk [7–9]. Itoi et al. popularize the idea of immobilization of the injured shoulder in an external rotation (ER) brace for several weeks during the acute phase to decrease the risk of recurrence [10]. They reported a 0% recurrence risk with the arm immobilized in the ER position compared to the regular sling in internal rotation (IR) which had a 30% incidence of recurrence. A recent meta-analysis of six randomized controlled trials comparing ER versus IR immobilization found no difference between the two groups in the recurrence rate [9].

Additionally, some individuals may not require immobilization versus others who may require 1–2 weeks of sling immobilization depending on symptoms, mechanism, and energy needed to dislocate the shoulder. Early passive motion of the glenohumeral joint is initiated within a protected range based on the individual's symptoms. Passive motion is performed in the plane of the scapula and diagonal patterns for maximal protection of the joint capsule and promotion of proprioceptive neuromuscular control required for dynamic stability. We perform ER or IR exercises at lower degrees of abduction and avoid exercises at 90° of abduction in the acute phase of injury to permit healing of the anterior capsuloligamentous injury. Early motion within the protected ranges may promote healing, enhance collagen organization, and aid in decreasing pain. Modalities such as ice and transcutaneous electrical nerve stimulation [11] may also be useful adjuvants to decrease pain, inflammation, and muscle guarding.

Restoration of dynamic joint stability is initiated in the acute and subacute phase. Muscle recruitment exercises, including pain-free submaximal isometrics, are initially used in the acute phase to minimize shoulder muscle atrophy. As symptoms improve, active-assisted motion is added in a restricted arc.

Stabilization and proprioceptive exercises are performed to reestablish dynamic joint stability. Closed kinetic chain exercises such as shifting weight against the wall or table within a protected range can be performed to help activate surrounding shoulder musculature and help restore joint proprioception. Rhythmic stabilization drills to facilitate muscular co-contractions in the scapular plane below 30° can also be performed. Scapular exercises to activate periscapular musculature are also important (Fig. 1). Neuromuscular electrical stimulation (NMES) of rotator cuff structures, particularly the posterior rotator cuff, may also be a helpful adjunct for muscular recruitment during the acute process.

Fig. 1 Rhythmic stabilization drills to facilitate shoulder musculature co-contractions in the scapular plane below 30°

Intermediate Phase After Injury—Phase II

Before individuals enter into this phase, certain criteria should be met that include reduced pain, satisfactory shoulder static stability, and adequate neuromuscular control. Objectives in this phase include attaining near full passive motion and active motion. Flexion and ER/IR exercises can be initiated at 90° of abduction, although ER at 90° abduction is typically limited to 45–50° until 4 to 8 weeks in order to avoid stressing the healing anterior capsuloligamentous structures. During this phase, the patient should achieve near normal passive and active range of motion [3] with the exception of ER at 90° of abduction.

Isotonic exercises are started during the intermediate phase with emphasis on internal and external rotators and scapular muscles to maximize dynamic stability. This typically occurs at 0° of abduction, which includes tube exercises along with side-lying ER and prone rowing. Rotator cuff exercises above 90° of abduction may be started once a stable arc below 90° is achieved. Closed kinetic chain exercises may be able to be progressed to hand-wall stabilization drills within scapular planes at increasing height as tolerated by the individual. Push-up exercises can be introduced at this phase of recovery to promote dynamic stability and core strengthening. Underlying scapular dyskinesis should be addressed prior to starting this. Push-ups are typically started with hand on a wall or table, then progressed to floor then an unstable surface (i.e., ball or tilt board) as the individual improves. Additional scapula, core, and hip exercises will assist with overall good stability and posture.

Advanced Strengthening and Return to Sport after Injury—Phase III

Individuals entering this phase should have achieved the following: (1) minimal to no pain in the injured shoulder; (2) full shoulder motion and capsular mobility; and (3) good strength (4/5 on manual test), endurance, and dynamic stability of the scapulothoracic and upper extremity. Progression of isotonic exercises is performed in this phase, particularly in functional positions for sports including at 90° of abduction. Because of the known association of fatigue, loss of neuromuscular control, and glenohumeral joint instability, exercises that are low resistance and high repetitions (20–30 repetitions) are incorporated into this phase of recovery. A gradual increase in resistance with isotonic exercises such as bench press, seated row, and latissimus pull-downs may be incorporated in protected ranges. Plyometric exercises that help improve neuromuscular control and train the extremity to produce and dissipate forces can be introduced. These may include two-handed throwing drills, such as chest pass, and progress to one-handed throwing drills against a trampoline.

Criteria for return to sport typically include the following: (1) full functional range of motion; (2) satisfactory muscular strength and endurance; (3) adequate static and dynamic stability; and (4) good clinical examination without pain. This phase is often individualized based on the individual's injury, sport, skill level, and goals. A common cited criteria within the literature to being an interval sport program is ER/IR strength ration of 66–76% or higher at 180° per second, and an ER to abduction ration of 67–75% or higher at 180° per second [12–15]. At our institution, we have utilized a shoulder-specific return to sport functional assessment and performance test similar to athletes returning from anterior cruciate ligament injury. Contact athletes, such as rugby and football athletes who do not require the arm to be in high abduction angles as a part of their position, may consider a shoulder-stability brace. The functionality of such braces is less useful for skilled position players and overhead athletes.

Efficacy of Rehabilitation in Prevention of Recurrent Anterior Instability

There is limited data on efficacy of rehabilitation programs that effectively reduces recurrence risk after anterior shoulder dislocation. Vermeiren et al. reported that those with recurrent instability event after an anterior shoulder dislocation reported significant lower visits with a physiotherapist (average of 15 daily sessions) versus those who did not have a recurrent instability event (average 47 daily sessions) [16]. In contrast, however, Kralinger et al. found that the age-adjusted rate of participation in physical therapy showed no association with recurrent instability [17]. These contradictory findings likely suggest that there are other confounding variables specific to the patient and the injury such as age, number of dislocations, and amount of glenoid bone loss on MRI or CT that are likely more important for recurrence risk than participation in rehabilitation. Better data that will address this question may be on the horizon. A prospective randomized multi-center clinical trial that will evaluate the efficacy of a supervised 12-week neuromuscular program versus a 12-week patient self-managed program in patients with traumatic anterior shoulder instability have been proposed to evaluate short- and long-term shoulder-related quality of life, risk of recurrence, and function [11].

Rehabilitation After Anterior Capsuloligamentous Repair—Arthroscopic or Open

The rehabilitation following anterior labral repair involves gradually restoring glenohumeral passive motion while protecting the healing capsuloligamentous tissue. Various patient- and injury-specific factors including patient age, tear characteristics (i.e., size, displacement, and quality of the tissue), associated pathology (i.e., glenoid and humeral head bone loss or osteochondral lesions), and security of the fixation of the torn tissue may affect how an individual progresses through the rehabilitation process. In the following sections, we present our institution's labral repair protocol (Appendix 1) as well our functional assessment and performance test as part of our return to sport decision-making process for individuals undergoing arthroscopic anterior labral repair (Appendix 2). This protocol places primary emphasis on progression criteria when transitioning to the next phase of rehabilitation, and post-operative time secondary. We find this practice allows for greater individualization and improved long-term outcomes of rehabilitation.

Phase I: Immediate Phase After Anterior Labral Repair (0–6 Weeks)

The immediate phase following arthroscopic anterior labral repair consist of maximal protection of the repaired tissue. While excessive micromotion that may disrupt of the tissue healing interface between the labrum and the glenoid bone should be minimized during the early healing process, it should be also recognized that gradual application of controlled stress is likely a stimulus to cause further proliferation and differentiation of healing fibroblasts and may promote collagen fibers being laid down across the repair [18–22]. Hence, typical individuals are placed into an abduction brace for relative immobilization the first 6 weeks after surgery in order to protect the shoulder from positions that may place the repaired tissue at risk. Positioning of the humerus into relative internal rotation may also be beneficial in reducing stress to the healing anterior capsuloligamentous tissue after surgical repair. There is no consensus on the period of shoulder immobilization following surgical anterior labral repair. Various authors have suggested 3–6 weeks of immobilization after labral repair [20, 23–25]. Kim et al. found in their randomized study that immediate motion in select group of patients (traumatic soft tissue Bankart repair) yielded in no greater recurrence rate dislocation or difference in pain or functional score compared to 3 weeks of immobilization [26].

During the first 2 weeks, passive ROM is initiated based on individual tolerance. Passive ROM is performed in diagonal, loose-packed positions during this phase for maximum protection. Forward elevation is limited to 60–75°, and ER is limited to 10–15° and IR to 45° in the scapular plane. Passive ER is avoided at 90° abduction for the first 6 weeks after surgery to protect the anteroinferior capsuloligamentous complex. At 3–4 weeks, the ROM is increased, but still restricted. Passive flexion to 90° and ER to 25–30° and IR to 55–60° in the scapular plane is permitted. Light strengthening exercises are performed to restore dynamic joint stability. This includes sub-maximal isometrics of shoulder musculature, rhythmic stabilization drills, and proprioceptive training. Gradual introduction of active-assisted ROM (AAROM) is performed in all planes, particularly diagonal patterns to promote proprioceptive neuromuscular facilitation. At 5–6 weeks, passive and active-assisted range of motion is progressed in all planes so long as the individual meets progression criteria. The objective of the first 6 weeks after surgery is to protect the healing of the repaired tissue, reduce pain, correct postural dysfunction, and promote dynamic stability, and restore passive- and active-assisted ROM in protected ranges to minimize the deleterious effects of immobilization, and promote organization and maturation of healing tissue through controlled mechanical stimulus.

Phase II: Intermediate Phase After Anterior Labral Repair (7–12 Weeks)

The objectives of the intermediate phase of recovery are to restore ROM and begin strengthening exercises for the rotator cuff and scapular stabilizers. ROM, which includes passive and active motion, is slowly progressed in all planes, including internal and external rotations at 90° of abduction. Light strengthening of external rotators and scapular stabilizers are performed. Blood flow restriction training and NMES are useful tools used during this phase for strengthening. NMES, particularly Russian electrical stimulation, may be used to facilitate appropriate timing and contraction of various shoulder muscles when performing exercise (Fig. 2). Additional strengthening exercises, particularly in 90° of abduction, are initiated after 10 weeks from the surgical repair. We typically begin incorporating the Thrower's Ten Program in this phase. Athletic activities that involve impact such as running are typically not initiated until intermediate recovery phase criterions are met, which includes full active ROM, satisfactory shoulder dynamic stability, muscular strength rated 4/5 or better, and no pain with exercises.

Blood flow restriction (BFR) training has been shown to be an effective way to increase muscle girth and strength in the shoulder [27•]. Low-load resistance training, when combined

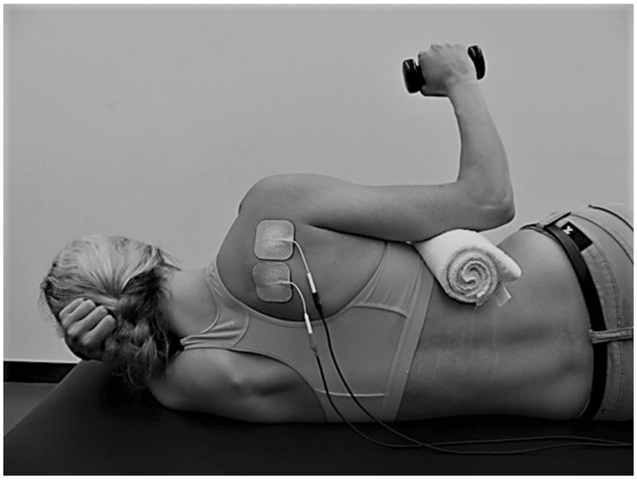

Fig. 2 Russian electrical stimulation of infraspinatus to facilitate appropriate timing and contraction of shoulder external rotation

with BFR training, results in greater strength gains than when used without BFR. The clinical relevance of this training includes the ability to achieve strength gains earlier in a rehabilitative period without requiring high-load exercises, many of which could be detrimental to healing capsuloligamentous structures in the early phases of rehabilitation. Varying protocols exist for application of BFR. Our institution utilizes BFR training for up to 15 min per session and up to two to three times per week (Fig. 3a–c). BFR training may be a safe form of strengthening in earlier phases of rehabilitation due to its benefits for increasing muscle size and strength regardless of an individual's ability to perform high-load resistance training [27•]. BFR training has also been shown to be effective when combined with neuromuscular electrical stimulation.

Phase III: Minimal Protection Phase After Anterior Labral Repair (12–20 Weeks)

The objective of this phase of recovery is to restore full ROM necessary for an individual's activities (sports, work), improve muscular strength, power, and endurance, and start functional (athletic) activities. Plyometric exercises are typically started at a low velocity and progressed to medium velocity in this phase. Strengthening exercises are continued and advanced from the previous phase, emphasizing dynamic control and combined lower body movements. It is important to regularly assess maintenance of ROM in this phase particularly internal rotation and posterior capsular extensibility. The cross body internal rotation stretch has been instrumental for gaining and maintaining internal rotation ROM at our institution (Fig. 4). Plyometric activities are advanced to higher velocity drills at 16 weeks if the athlete demonstrates good control, mechanics, and minimal to no compensation during light to moderate drills. It is at this point that an interval sport program, including throwing, swimming, or other overhead sports may be initiated. Individuals who are not an overhead athlete may be able to return in this phase. Competitive overhead athlete and throwers typically may not return to full competition until 7–9 months after surgery. We typically use a functional assessment and performance test in conjunction to their clinical examination to evaluate an athlete's readiness to return to full sport participation.

Criteria for Return to Sport After Shoulder Anterior Labral Repair

Unlike athletes and ACL injury [28–30], there is limited data on return to sport criteria following arthroscopic anterior labral repair. There is little evidence that exists regarding physical return-to-play criteria of the shoulder after injury much less after repair including lack of valid assessment tools. In general, most would agree that aspects of shoulder examination that would be of interest in the decision for return to sport include assessment of glenohumeral ROM, rotator cuff strength, scapular position and strength, and functional performance tests. Matheson et al. proposed a three-step return to sports model that is applicable to patients after shoulder

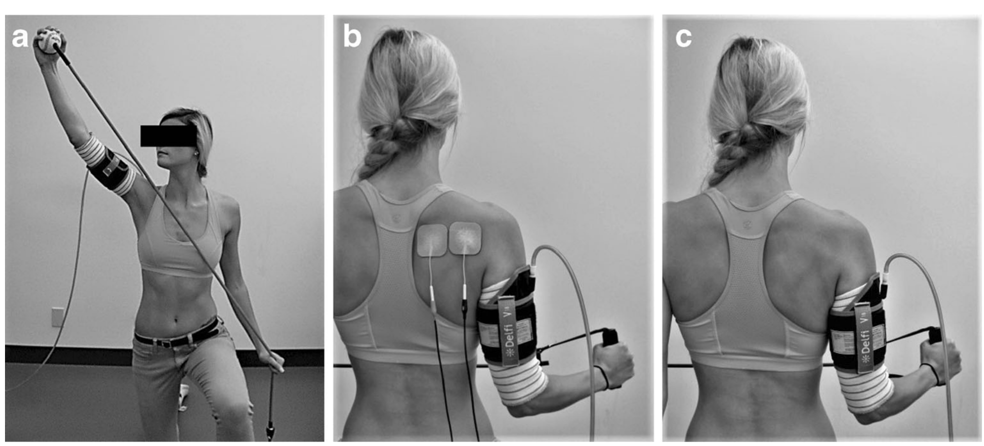

Fig. 3 **a**–**c** Use of blood flow restriction during diagonal exercises (**a**) and external rotation band exercises with (**b**) and without (**c**) Russian electrical stimulation (**b**) to promote muscle strength recovery

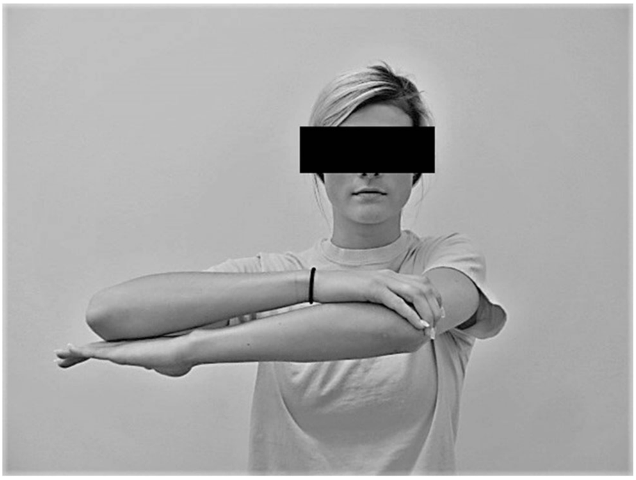

Fig. 4 The cross body internal rotation stretch for gaining and maintaining shoulder internal rotation

stabilization surgery [31]. First step is to evaluate the patient functionally with assessment of symptoms, range of motion, strength, and health status. Second step is that the clinician must evaluate the participation risk based on the type of sports and the ability of the athlete to protect his or her shoulder. The last step is evaluating the modifiable factors including timing of the season and environment prior to clearance to return to sports. All of these above factors are important in the assessment of the athlete after shoulder surgery before returning them back to full activities and sports participation.

Deficits in glenohumeral motion, particularly in internal rotation, have been associated with shoulder pain and risk for injury in overhead athletes. Internal rotation deficits ranging from 18 to 25° has been associated with increased risk of injury [32, 33•, 34•, 35]. Therefore, in our institution's return to sport assessment, we advised a side-to-side difference in internal rotation ROM should be < 18°, and the total arc of motion (combined values for internal and external rotations) difference should not be more than 5° [32]. In terms of rotator cuff strength, an isokinetic ER/IR ratio of 66% or an isometric ER/IR ratio of 75–100% has been advised with the dominant shoulder typically 10% higher than the non-dominant side [12–15]. Johansson et al. demonstrated good to excellent reliability for measuring eccentric external rotation strength using a hand-held dynamometer [36], which we have started to incorporate in our return to sport assessment.

While shoulder range of motion and strength may be easily assessed and more readily available in the literature, data on scapular mechanics and symmetry and its importance in prevention of reinjury after shoulder injury or surgery is limited. The lower trapezius and serratus anterior have been associated with weakness after injury in athletes [12, 37, 38]. However, in certain instances, asymmetry in scapular mechanics have been questioned in terms of clinical value and may be considered adaptive for certain sports [39–41]. Based on normative studies, cut-off values for upward rotation of the scapula is approximately 60° in full arm elevation with a 10% increase in strength in the dominant shoulder in single-handed sports (i.e., tennis, volleyball), and equal strengths on both sides in bilateral sports (i.e., swimming) [42, 43, 44•]. Within our institution's functional assessment and performance test (Appendix 2), we have evolved to using a hand-held dynamometer to assess shoulder girdle muscle strength.

Functional performance test for shoulder after injury and repair is an area of interest. While tests such as the Y balance, closed kinetic chain upper-extremity stability test (CKCUEST), and seated medicine ball throw have been described to evaluate static weight-bearing stability and front chest throwing performance respectively, the threshold at which a particular performance equates to prevention of re-injury is not known [45–47]. We utilize functional tests, such as Selective Functional Movement Assessment (SFMA) and Y balance, to enhance the full clinical picture when assessing an athlete's readiness to return to unrestricted play. Many competitive overhead sports (baseball, swimming, volleyball) involve full body, rotational movement. Therefore, an athlete's full kinetic chain is assessed for limitations that would potentially result in additional strain to the upper extremity.

Conclusion

In conclusion, rehabilitation after an anterior shoulder instability and anterior labral repair is paramount in not only restoration of the injured or operative shoulder function but also potentially minimizing future re-injury risk. While certain objective parameters, such as range of motion and rotator cuff strength, are felt to be important to normalize during the rehabilitative process after injury and repair, other parameters, such as scapular rotation and strength, are less clear. Performance in functional tests as it relates to injury prevention is also not clearly established. Return to sports after surgical repair should be based on range of motion testing, restoration of neuromuscular control, strength, and functional testing. With the limited available evidence-based literature, there is a need for continued work in the area of rehabilitation after anterior shoulder instability injury and repair.

Compliance with Ethical Standards

Conflict of Interest Xinning Li reports equity from and is an editorial board member of JoMI. All other authors declare that they have no conflict of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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