Injury Prevention and Return to Competition
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Helping an athlete recover quickly and effectively from a sport-related injury is a major priority for any strength coach. With the high intensity of competition, injuries are inevitable; consequently, the strength coach must be familiar with proper practices and how to work cohesively with other support staff during the recovery process. Of even greater importance is a clear understanding of how to prevent injuries, or limit their impact during a competitive season. To put this in perspective, a recent review of injury profiles for all players entering the Women's National Basketball Association (WNBA) between 2000-2008 showed that 47.8% of the players had previous ankle sprains, 20.8% hand injuries, 17.0% patellar tendinitis, 15% ACL injury, 10.5% meniscus injuries, 7.3% stress fractures, and 7.1% concussions [1]. The ankle was determined to be the most common site of injury and ACL reconstruction the most common surgery among these elite female athletes [1]. Even though the history of injury or surgery did not affect the round drafted or career length, the numbers were high. Obviously, strength coaches must ensure applicable “prehab” and rehabilitation activities are part of their professional toolbox for dealing with the various challenges of keeping his or her athletes contributing to the team’s competitive success.

When an athlete sustains a sport-related injury, one of the first questions raised invariably focuses on the subject of when he or she can start playing again. Unfortunately, there is rarely a clear-cut answer to this question. The desire to avoid lost opportunities and deconditioning must be carefully balanced with the risk of re-injury and possibly permanent disability. In practice, the question of return to sport does not merit a simple yes or no answer, but rather involves degrees of physical readiness that are increased in a slow, graded manner from the strictest precautions to unrestricted competitive performance. The athlete’s transition is guided by physicians, physical therapists, athletic trainers and strength and conditioning coaches; in truth, optimal recovery from a sports injury requires a team of individuals who possess expertise in different fields. It is important to keep the lines of communication open between all members of this team to ensure the athlete is receiving the best and most appropriate level of training throughout the recovery process. Too often, athletes are re-injured when undergoing activities that are inappropriate for their level of healing; conversely, failure to increasingly advance training results in loss of valuable time.

Recovery from sports injury can be divided into three major phases: the acute phase, the intermediate phase, and transition to sport. Physical therapy protocols may subdivide these phases, especially the intermediate phase, in order to specify or more precisely define what therapies should be implemented, and under what circumstances they should be employed. However, for the purposes of broad understanding of the athlete’s recovery plan, the identification of these three phases is sufficient [2].

The acute phase begins at the onset of injury. Its end is marked when symptoms have subsided enough to allow the athlete to carry out basic non-athletic activities. Emphasis during this period is on appropriate protection of injured tissues as well as minimizing pain and inflammation.
It is important early on that the athlete receives a complete and accurate diagnosis. This includes evaluation by a physician. Ideally, a certified athletic trainer or sports physician was present during the event to collect relevant data on the mechanism of damage and provide immediate support to limit further injury. Quality health and injury history data is often very helpful in the diagnosis and treatment of the injury. In addition to a good history and physical examination, evaluation may require some type of diagnostic imaging, such as an X-ray, computed tomography (CT) imaging, magnetic resonance imaging (MRI), electrodiagnostics including electromyography (EMG) and nerve conduction studies (NCS), or bone scan [2]. A thorough investigation into the injury is essential. Serious conditions may initially seem like a minor issue and may be missed if not clinically ruled out. This is common of bone injuries. A tibial stress fracture, for example, may be dismissed as “shin splints” and progress to become a large, disabling fracture if insufficiently investigated. There may also be more than one injury at once; a more obvious injury may conceal damage elsewhere with more subtle symptoms, but equally catastrophic long-term consequences, if left untreated.

Depending on the nature of the injury, the acute phase may last from 24 hours to approximately one week. Early physical therapy may be initiated at this time, which tends to involve the most gentle and conservative of maneuvers [2]. These include range of motion (ROM) movements that are passive and limited so as to avoid the terminal end of physiological range. Pain control may be achieved using a combination of methods, including anti-inflammatory medications, analgesics, and various therapeutic modalities.

In the intermediate phase, the bulk of care is provided by a physical therapist. Appropriately slow, graded advancements are made in strength, flexibility, and endurance. The physical therapist should be aware of major precautions, such as avoiding overly aggressive stretching techniques for some conditions. The physical therapist will also set achievement-based criteria for advancing the difficulty of exercises; for example an athlete with a knee injury may need to demonstrate full knee extension before quadriceps strengthening begins. Physical therapists collaborate with other practitioners during this phase which may include exercise physiologists, physical therapy assistants, occupational therapists, athletic trainers, and personal trainers.

An important note is that some practitioners are more aggressive than others, so outcomes may vary among athletes with similar conditions when treated by different physicians and therapists. Therefore, next-level readiness may be defined differently among medical staff. Strength coaches and athletic trainers should define specific criteria for athletes re-entering the athletic environment.

While some injuries are purely accidental, many involve modifiable elements. These include suboptimal biomechanics, imbalances between antagonist muscle groups, inflexibility, and poor proprioception. The intermediate phase is the best opportunity to identify these correctable factors, and fully address them. Technique-oriented issues, another major contributor to injury, are best addressed during return to sport.

Muscle strength and endurance are key components to rehabilitation and injury prevention. When sufficiently strengthened, dynamic restraints to a joint (muscles used for force closure) can take greater responsibility for stabilization in lieu of failing static restraints such as torn ligaments (compromised form closure). Exercises used in rehabilitation are classified as isometric, isotonic, and isokinetic. Isometric exercises are executed first, when ROM limitations are greatest. Since isometric exercises do not produce a change in the joint angle, they place less stress on sensitive

**DEFINITIONS**

**Electromyography** – The recording of the electrical activity of muscle tissue using electrodes attached to the skin or inserted into muscle

**Isokinetic** – When referring to a skeletal muscle contraction, denotes a regulated and constant speed of movement to ensure the action can only be performed a specific velocity
or dysfunctional ranges of the joint while allowing the muscle to still become activated. Traditional isotonic exercises are initiated later in the therapy process. Due to the fact that these exercises, in contrast, occur over a greater ROM they provide more stress upon the joint and its associated architecture. A classic example of an isotonic exercise would be a bicep curl. Isotonic exercises may be concentric or eccentric, depending on whether the muscle is shortening or lengthening as it contracts, which offers some diversity in the exercise selection. In some cases, the eccentric contraction is emphasized to take advantage of the added force capabilities during the lengthening phase. A single-leg squat (pistol) decelerated to a bench would be an example.

Eccentric exercises are a key component of many rehabilitation strengthening programs, as deceleration allows for more control than acceleration and produces greater forces per muscle fiber than an equivalent concentric contraction. Isokinetic exercises involve variable force generation to maintain a constant velocity through a muscle’s range. These exercises are highly effective and efficient for muscle conditioning, but generally require specialized equipment such as a Biodex.

Ballistic and plyometric exercises are commonly used late in the intermediate phase, when the athlete has recovered a significant amount of strength. These exercises accelerate the strengthening process by taking advantage of the stretch-shortening cycle. This strategy increases power in a given movement by taking advantage of the muscle’s inherent stretch reflex which increase force output during the concentric movement phase. However, it does place high stress demands on working tissue and should therefore be moderated by intensity relative to the athlete’s previous capabilities. These exercises are particularly effective for preparing the athlete’s neuromuscular system to react quickly to abrupt changes in force and velocity, which are critical for injury prevention.

The most effective physical therapy analyzes and improves the function of the entire kinetic chain. Therefore, therapies must focus on the interactive relationship between all body segments involved in a given movement. During a tennis serve, for example, the kinetic chain involves not only the hand, arm, and shoulder, but also the torso, hip and lower extremity. These components are connected in an orchestrated manner designed to accelerate movement segments while managing external force such as the shock from the racquet upon ball contact. Anterior acceleration must also be consistent with posterior deceleration, placing greater emphasis across the shoulder, spine and hip musculature to maintain postural control throughout the action. All problems of varying severity within the kinetic chain, from back weakness to ankle inflexibility, should be addressed during rehabilitation and often function best using an integrated approach.

From this standpoint, exercises may be categorized as isolated or coordinated. Isolated exercises are often employed earlier to promote localized activation and usually use an open kinetic chain. Once pain management and ROM allow for coordinated actions, closed kinetic chain activities can populate the exercise selections. Open chain exercises are selected to isolate free distal limb actions without the responsibility of bearing and stabilizing body weight, where closed chain exercises in contrast, may or may not involve weight bearing, but require a fixed distal limb. A common example is the lat pull-down exercise versus the pull-up exercise. The lat pull-down is considered an open chain activity as the machine stabilizes and supports the body whereas the pull-up requires the body to bear its weight and stabilize the movement. Closed kinetic chain
exercises are believed to enhance proprioception and minimize shearing forces in a manner that cannot be achieved using open chain exercises. Likewise, they encourage central-peripheral stability (local and global stabilizers) using reaction forces in addition to the accelerator forces produced by the global movers.

The transition to the sport phase is initiated when the athlete has demonstrated the return of normal strength, flexibility, and other basic performance parameters. This phase may be overseen by a physical therapist, but is normally transitioned to the athletic training department and strength coach who assume primary training responsibilities for the athlete. Unfortunately, athletes at a lower level of competition may not have any guidance during this critical period.

The belief that the athlete is prepared to return to full competition at this point is faulty and leads to a high rate of re-injury. Strength and conditioning coaches must realize that rehabilitative activities are directed at a particular outcome which is measured by relatively simple physical measures. Sports activities on the other hand require much more from a joint than its requisite movements. Even in a single action, such as kicking a soccer ball, the body functions through integrated movement patterns which are all dependent on the foundations of strength, endurance, and flexibility re-established during the rehabilitation process. Clearly, musculoskeletal proficiency developed using functional movement patterns is needed not only to regain skills that might have been lost during recovery, but also to prevent new injuries when the athlete fully returns to play.

The sport phase has two important components, sport-specific drills and an integrated training program. The two may occur at the same time in some conditions, while other situations demand consistent success with drills before the integrated program can be started. Sport-specific drills isolate particular activities essential to the sport. Integrated training programs, in contrast, are specific, day-by-day plans for safe return to full athletic participation. They explicitly describe the duration and type of exercise for each day.

When the transition to the sport phase has been completed, it is important to maintain any corrections acquired during the recovery process. For instance, gains in flexibility will be lost without some level of maintenance in the sports phase and beyond. In many cases, the corrective strategies should be further emphasized in the training program. This minimizes the risk of future injuries, and allows the athlete to confidently return to play with the tools for maximal performance.

◆ Common Sports Injuries

**Stingers**

Associated Activities: Football, rugby, hockey

**Stingers** are thought to originate from one of two anatomic structures: the brachial plexus and the cervical spinal nerve. A “stinger” or “burner” is characterized by a short-lived stinging or burning pain in the neck and arm due to trauma. They are generally seen in collision sports such as football, hockey and rugby. In addition to pain, the athlete may feel numbness in the affected arm and weakness of the muscles around the shoulder. The symptoms are always one-sided, and typically resolve within seconds to minutes of the initial onset. Two mechanisms of injury have been proposed. The first is traction on the brachial plexus, which occurs with forceful depression of the shoulder and abduction of the neck in the opposite direction. This
DEFINITIONS

Cervical stenosis –
An abnormal narrowing of the spinal canal in the cervical region that causes impingement of the spinal cord and consequent symptoms such as spastic gait, extremity numbness/weakness, and/or sensory deficits

Acromioclavicular separation –
Also known as a “separated shoulder”, most commonly occurs during a direct fall onto the tip of the shoulder; as a result of this trauma, the connection between the clavicle and the acromion of the scapula is significantly disrupted

kind of injury is more likely to occur among junior athletes that are less adept at proper tackling and checking technique. The second proposed mechanism is a compression of the nerve root as it exits the cervical vertebrae, which occurs with neck extension and adduction towards the affected side [3,4,5]. This type of mechanism is seen with helmet “spearing”. Cervical stenosis (abnormal narrowing) and cervical disc disease may contribute to the likelihood of a compression-type stinger injury to the cervical spinal nerve; radiographic imaging (i.e., x-ray, CT, MRI) may be required to fully evaluate this condition [3,4,5].

While stingers typically do not last for more than a few minutes, complete resolution may not occur for several days. Symptoms lasting more than 24 hours, bilateral symptoms, or involvement of the lower extremities warrant a more extensive medical evaluation, especially for injuries involving the blood vessels, brain and spinal cord. Longer lasting weakness may require electrodiagnostic evaluation [3,4,5].

Guidelines on returning to sport depend strongly on the history and severity of symptoms. If the athlete has suffered a first- or second-time stinger and the symptoms completely resolve within a few minutes, immediate resumption of play is generally considered safe. If symptoms linger, the athlete should not be permitted to return to activity until all sensory disturbances and weakness have completely disappeared. More worrisome injuries, such as those that are recurrent (3 or more times) or with symptoms for more than 24 hours, should undergo full evaluation before the athlete is cleared to play again. Repeated stingers may result in chronic pain and weakness. Ongoing neurologic deficits (numbness, weakness) and multiple recurrences are indications that complete withdrawal from contact sports may be warranted. Return to play parameters include: resolution of symptoms, return of strength, as well as normal measures of mobility and neurologic function [3].

Treatment is largely supportive, involving rest and pain control. Physical therapy programs for ROM preservation and upper body strengthening may be beneficial, although care should be taken to avoid aggravating movements and positions. As a general rule, actions that mimic the conditions of the original injury should not be permitted during therapy and exercise. Tackling, blocking and checking techniques should be examined and modified as necessary; avoidance of helmet “spearing” and dropping the shoulder at contact are particularly important. When athletic activity is recommenced, high-riding shoulder pads may be helpful in absorbing shock to the area; neck roll devices fitted to prevent lateral neck movement may also prevent recurrence [3,4,5].

Acromioclavicular (AC) Separation ("Separated Shoulder")

Associated Activities: Football, rugby, hockey, weightlifting

Acromioclavicular (AC) separation, also called “separated shoulder” is an injury inflicted most commonly during a direct fall onto the tip of the shoulder. As a result of this trauma, the connection between the clavicle and the acromion of the scapula is significantly disrupted. The athlete will present with pain and, most often, obvious deformity over the affected joint. AC separation is classified as grade I-VI, based on the severity of the injury. Grades I and II are treated conservatively, while grades IV-VI are addressed surgically. There is still extensive debate about whether grade III injuries should be managed surgically or non-surgically [2,6,7].

Conservative treatment begins with pain relief through use of a sling, generally for 1-6 weeks. Ice and other modalities are used for pain. Early mobilization of the shoulder
is performed as tolerated. Initial physical therapy includes pendulum exercises, elbow ROM activities and rope-and-pulley exercises, as permitted by symptoms. Taping of the AC joint may also help with pain and the athlete’s sense of shoulder stability. After ROM returns to 75% of normal, gentle progression of strengthening exercises may be initiated.

More severe grades of AC separation require surgery, and postoperative restrictions are typically dictated by the surgeon. A sling may be strictly required during the initial stages of recovery, with a regression from full-time application to reduced use over an approximate 12-week period. Frequently, ROM is restricted to 90° in all planes of movement for the first 4 weeks after surgery. However, pendulum exercises may be performed as tolerated. As pain recedes and successful healing is confirmed, increasingly aggressive strengthening of the shoulder girdle can be undertaken. Strengthening of the deltoid and trapezius musculature is particularly beneficial to stabilization of the AC joint. At this time, general shoulder rehabilitation including scapular stabilization and rotator cuff strengthening is added to the therapeutic regimen. Shoulder abduction and bench pressing are the last exercises to be added as these exercises place high biomechanical stress through the AC joint and have been implicated as a cause of injury. AC separations are not uncommon in elite power lifting and weight training for American football due to the heavy loading placed in horizontal adduction.

Athletes may return to play after achieving a normal pain-free ROM, although the timing of this benchmark varies widely with the severity of the injury and whether or not surgery was performed. A sensation of some instability in the joint may be present until the return of normal strength, which may not occur for up to a full year. After surgery, contact sports may be prohibited for up to 6 months.

**Shoulder (Glenohumeral) Dislocation**

Associated Activities: Basketball, football, gymnastics, volleyball

The shoulder is the most commonly dislocated large joint. Dislocations are nearly always traumatic, occurring after an injury that places the shoulder in forced abduction and external rotation. Relocation, or reduction, of the shoulder should be performed as soon as possible by an experienced clinician to minimize risk of damage to nearby cartilage, nerves and surrounding soft tissues. Dislocation is commonly associated with damage to the glenoid labrum (Bankart lesion) and bony components of the shoulder joint (bony Bankart and Hill-Sachs lesions). Athletes who experience one traumatic shoulder dislocation demonstrate a greatly elevated risk for repeat dislocations; with recurrence rates in the literature ranging from 40-90%.

Even if dislocation does not recur, there is high risk of decreased performance due to subluxation and sensation of instability.

While shoulder dislocation may be due purely to trauma, many factors intrinsic to the athlete may increase glenohumeral instability. These include weakness of scapular stabilizers, insufficiency of stabilizing glenohumeral soft tissues, and inadequate proprioception. In throwing athletes and swimmers, anterior capsule laxity and posterior capsule tightness also contribute to risk. A traumatic dislocation is often seen in individuals with congenital ligamentous laxity, sometimes present in both shoulders. The vector of dislocation in these cases can be multidirectional. Surgical results are variable and the mainstay of treatment surrounds rehabilitation with an emphasis on scapular and rotator cuff stability. Individuals presenting with significant joint laxity should be assigned a specific strengthening program aimed at improving strength of the surrounding tissues. Emphasis
should be placed on local and global shoulder stabilizers to avoid or at least reduce the risk of dislocation.

Previously, first-time traumatic dislocation was either acutely addressed with no follow-up care, or treated with a course of physical therapy. However, increasing evidence indicates that surgical stabilization and repair may prevent repeated glenohumeral instability. Given the longer period of recovery from surgery, though, a preferred course of action after one dislocation may be to undergo conservative management of injuries occurring during the season, followed by operative treatment after the season has ended. If a second dislocation takes place, intrinsic instability is highly likely; in this case, further activity should be avoided until after a full evaluation of the contributors to instability has been completed.

Rehabilitation after glenohumeral dislocation varies widely in restrictions, progression, and duration of time. Several factors will affect the aforementioned including whether or not surgery was employed, the nature of the procedure, and surgeon-specified restrictions. Traditionally, sling immobilization in internal rotation was implemented for 3-6 weeks. More recent studies have found that some degree of external rotation may be of greater benefit, others suggest that use of sling immobilization does not alter long-term outcome. As with all shoulder rehabilitation, strengthening of the scapular stabilizers and the entire kinetic chain is a key component. Sensorimotor system training is initiated early. Rehabilitation protocols may last up to 9 months, but accelerated protocols as short as four weeks may be applied under certain conditions.

Requirements for return to activity include lack of pain and full ROM. Additionally, iso-kinetic testing should indicate that the injured side is capable of performing at a level equal to at least 90% capacity of the unaffected side. The shift from rehabilitation to full performance should be bridged by approximately four weeks of a sport-specific training program. A maintenance program for ROM and strength should be continued indefinitely. During the return to play training period, the athlete should be carefully monitored for any pain or recurrent instability [9,10,11,12].

**Shoulder Impingement Syndrome**

Associated Activities: Baseball, softball, football, swimming, water polo, golf, tennis, volleyball

**Shoulder impingement** can be categorized as external or internal, based on whether the main lesion is subacromial or glenohumeral. External impingement is further subdivided into primary and secondary impingement. Primary external impingement is due to congenital or acquired structural abnormalities of the acromion and subacromial space, such as a hooked acromion or osteophyte formation. Unlike the other two types of impingement, primary external impingement is less due to overuse and rather dependent on intrinsic factors specific to the athlete. The physical findings and treatment differ somewhat from those of overuse injuries, but basic principles of rehabilitation in conservative management remain the same [13,14].

In contrast, secondary external impingement is an overuse phenomenon in which insufficient scapular stabilization causes dynamic impingement of the acromion upon the subacromial space. This excessive scapular movement is due to weakness or strength imbalance of the scapular stabilizers (middle and lower trapezius, rhomboids, pectoralis minor and serratus anterior). Impingement is common and predictable in individuals presenting with postural disturbances, particularly anterior migration of the humeral head. Impingement syndrome is often associated with some combination of the following: repetitive overuse – particularly from ballistic overhead
movements, weight training with excess focus on anterior muscles, and imbalances between pushing and pulling muscles. Impingement first manifests as inflammation of the subacromial bursa \[13,14\]. As wear continues on the bursa over time, its cushioning ability is compromised and the rotator cuff tendons underneath begin to degenerate and tear. Prior to the presentation of pain, the athlete may complain of diminished shoulder performance, as evident by a decrease in velocity or control. If pain occurs, it is generally located in the anterior or lateral shoulder with overhead movement. However, it is important to remember that localization of shoulder pain is often poorly correlated with the underlying pathology; a thorough history, physical examination, and appropriate imaging are critical to an accurate diagnosis \[13,14\].

Early rehabilitation of external impingement focuses on avoiding acts that cause pain, increasing ROM inclusive of the joint capsule and improving muscular balance with a special focus on scapular stabilizers. In addition to avoiding painful movement, pain intervention entails use of ice and anti-inflammatory medications. Training ROM should be limited and always pain-free. Goals include abduction to 90° as well as internal and external rotation at 45° of abduction. Strengthening focuses on scapular stabilization and rhythmic stabilization for rotation and flexion/extension. Therapists may use different modalities to reduce inflammation and encourage healing including cryotherapy, ultrasound, and phonophoresis. Athlete education on correct posture with shoulder retraction should also be provided; this is particularly relevant for athletes with voluntary slumped shoulders and visibly poor seating postures. As pain decreases and muscular balance is achieved, a more complete ROM can be integrated, and muscular strength can be normalized. Special attention must be made to restoring internal rotation as the posterior glenohumeral capsule is often tight with relative laxity in the anterior capsule in overhead athletes. It is important to recognize the specific deficits or abnormal kinetics in each individual, as correction of the underlying pathology is critical to recovery and avoidance of re-injury. Sometimes exploration down the kinetic chain is needed to discover underlying biomechanical deficits that may have predisposed the athlete to overuse of the rotator cuff \[13,14\].

As the athlete transitions back to activity, a maintenance exercise program should be implemented to ensure retention of anterior and posterior muscular balance as well as ROM. Emphasis is placed on posterior rotator cuff strength. Unlimited pain-free activity is permitted at this phase. An integrated sport program should be started to resume activity at a safe pace and to ensure proper technique.

As alluded to previously, when stating the importance of rhythmic stabilization within the shoulder complex, the professional dealing with an athlete recovering from shoulder impingement or other form of associated dysfunction such as glenohumeral internal rotation deficit (GIRD) must be familiar with proper scapulohumeral rhythm. Scapulohumeral rhythm describes the movement of the scapula across the thoracic rib cage in relation to the humerus during elevation of the shoulder. This rhythm is compromised by any issue that alters the resting or active positioning of the scapula. During normal rhythm, the first 30° of shoulder elevation (abduction) is primarily driven by the glenohumeral joint, with minimal movement of the scapula (scapulothoracic action). After the first 30°, both joints should act simultaneously at an approximate 2:1 ratio of glenohumeral to scapulothoracic movement. Palpating the scapula’s position during elevation can be useful for assessment of rhythm; helpful landmarks include the base of the spine and the inferior angle \[2,6,7,12,13,14,15\].

### Definitions

**Bursa**

A tiny fluid-filled sac that functions as a gliding surface to reduce friction between tissues of the body.

**Cryotherapy**

Localized or whole-body exposure to subzero temperatures to decrease inflammation, increase cellular survival, decrease pain and spasms, and promote overall health.

**Ultrasound**

Ultrasonic waves or sound waves of a high frequency pass from the treatment head into the skin causing vibration, which produce heat within the surrounding tissues, particularly those that contain collagen.

**Glenohumeral internal rotation deficit**

A notable difference in internal rotation capacity in the dominant shoulder when compared to the non-dominant shoulder; very common among throwing athletes.

**Scapulohumeral rhythm**

Describes the movement of the scapula across the thoracic rib cage in relation to the humerus during elevation of the shoulder; can be compromised by any issue that alters the resting or active positioning of the scapula.
Scapulohumeral rhythm serves two major purposes. First, it functions to preserve the length-tension relationships of glenohumeral musculature to allow for sustained force through a greater ROM. For example, during an overhead press, the anterior and medial heads of the deltoid do not shorten as quickly as they would without the simultaneous upward rotational movement in the scapula. Secondly, it helps to prevent impingement in the subacromial space between the humerus and the acromion. Faulty rhythm places the scapula in compromised or less effective positions for force transfer during many shoulder complex actions. The literature does not seem completely consistent with regard to the scapula's resting position, but the scapula is usually positioned approximately horizontal, internally rotated by 35°, and with a 10° anterior tilt \( [2,7,12,13,14,15] \). Many distortions to this position can occur with repetitive movements, imbalanced training protocol, and high-volume ballistic overhead activity as described earlier. During normal shoulder abduction, most researchers concur that the scapula tilts posteriorly and rotates both upward and externally. Patients with shoulder impingement syndrome generally demonstrate decreased upward scapular rotation, a decreased posterior tilt, and a decrease in external rotation during the same movement. In this case, rhythm would be greatly disrupted. Those with impingement also demonstrate greater scapular upward rotation and clavicular elevation during flexion of the shoulder. These examples may help to explain some of the cause for limited ROM or faulty movements which commonly occur during overhead pressing or other actions involving shoulder flexion with impingement. In all actuality, those with shoulder impingement demonstrate limited ROM, reduced force capacity, and distorted rhythm during movement in all directions, when compared with their healthy counterparts.

To summarize, abnormal scapulohumeral rhythm will predispose an athlete to shoulder complex injuries and inefficiency. Disturbed scapulohumeral rhythm may be detected via direct palpation or visual inspection of altered scapular dynamics during scapulohumeral movement. These alterations can include: excessive scapular rotation (and other movements) during shoulder abduction due to reduced rotator cuff control, hitching in the scapula due to upper trapezius dominance, winging of the scapula due to serratus anterior dysfunction and excessive forward tilting of the scapula due to an overactive and tight pectoralis minor.

**Rotator Cuff Tear**

Associated Activities: Swimming, tennis, baseball, football

The rotator cuff consists of four muscles and their associated tendons: the supraspinatus, infraspinatus, subscapularis and teres minor. These muscles attach to the scapula and the humerus, and are critical to shoulder stability. Tears are most often found in the tendon of the supraspinatus muscle. While approximately 5% of tears are due to trauma, the remainder is associated with chronic conditions. Chronic tears are most likely part of a spectrum of tendon degeneration, from tendinopathy to a complete tear \( [2,7,8,15] \). These injuries are due to a combination of factors, which include repetitive microtrauma, insufficient blood flow, disuse and age-related deterioration. An athlete with a chronic tear will complain of shoulder pain worsened with activity, often accompanied with weakness and decreased performance (power and accuracy). In contrast, athletes with acute tears will complain of a sudden onset of pain and significant limitation to ROM; they may be unable to abduct the affected shoulder. Tears can vary widely in size and severity, which dictates both length of recovery and the approach to treatment. In general, partial thickness tears are treated conservatively and full-thickness tears require surgery.
Rehabilitation of a rotator cuff tear must be undertaken with awareness of the “rotator cuff paradox”; too much movement too soon will result in re-injury, but too little motion results in undesirable stiffness. Any therapy must strike a careful balance to avoid either of these adverse outcomes. Immediate therapy focuses on pain control and improving ROM with prescribed restrictions. Pain control may include use of non-steroidal anti-inflammatory drugs (NSAIDs), ice, heat, and a sling as well as steroid injections in athletes being treated conservatively. Modalities with inconclusive evidence as to their benefit in rotator cuff tears include electrotherapy, ultrasound, low level laser therapy (LLLT), and extracorporeal shock wave therapy (ESWT). Specific ROM limitations and timing will depend on which tendon is affected as well as whether or not surgery was performed. Scapular stabilization exercises may also be done in isolation, taking care to avoid activating the rotator cuff. Gradually, a functional ROM is achieved and rotator cuff strengthening exercises begin. Slow, deliberate exercises are often used to enhance proprioception. For throwing athletes, any GIRD should be addressed, as should any posterior capsule tightness. As the athlete nears the end of the acute rehabilitation process, plyometric exercises and sport-specific activity is used in preparation for return to training. Before release from rehabilitation and return to competition, the athlete should demonstrate equal strength and mobility on the affected and unaffected sides [2,7,8,15].

The transition back to sport should be achieved with a sport-specific integrated training program. For throwing sports, many integrated throwing programs have been written with explicit instructions on the type and quantity of activity that should be performed each day, and specify an appropriate rate of increase in training intensity. In general, an integrated sports program will begin with gentle sport-specific activity for short periods of time (30 minutes to 1 hour) every other day with cross-training performed on the off days. As with all training programs, increases in intensity (including adjustments to duration, repetitions, weight, and speed) should be small and incremental [2,7,8,15]. A conditioning regimen, which may be developed in partnership with the physical therapist or athletic trainer, should be used during and after return to sport in order to ensure the continuity of proper glenohumeral, scapular, and core kinematics.

**Glenoid Labral Tear**

Associated Activities: All throwing sports, swimming

The glenoid labrum is a cartilaginous ring lining the outer edge of the glenoid fossa of the scapula, which acts to deepen the “socket” portion of the glenohumeral “ball and socket” joint. It is often stated that the glenohumeral joint is not a true ball and socket, giving up stability for mobility. The added mobility increases shear and frictional stress to the soft tissues that provide articular support. Tears to the glenoid labrum may be traumatic or degenerative and may manifest as pain in the posterior or superior aspects of the shoulder, as well as diffuse pain felt “deep” within the joint. The athlete may also report clicking, grinding, catching or popping sensations. This injury is very commonly seen in association with other shoulder pathology, including biceps tendinopathy, rotator cuff pathology, and shoulder dislocation [2,16].

For treatment purposes, labral tears are categorized into “SLAP” and “non-SLAP” tears. “SLAP”, or Superior Labrum Anterior to Posterior, refers to damage on the superior aspect of the labrum which is present both anterior and posterior to the attachment of the biceps tendon. SLAP tears are nearly always seen with concomitant biceps tendon injury. This injury is most closely associated with overhead throwing athletes, who have biomechanical changes (i.e., GIRD, external rotation excess, anterior capsule laxity) that predispose them to injury. “Non-SLAP”
tears encompass a number of mechanisms of injury, including shearing of the labrum by the humeral head during traumatic dislocation [2,16].

For athletes, labral tears are generally managed surgically. If stable, a debridement or “cleaning up” is sufficient. When unstable, or when large lesions exist, full repair is required. Recovery time and aggressiveness of rehabilitation depends on many factors, including the specific lesion as well as whether a debridement or repair was performed. After debridement, a sling is used for 1-2 weeks for comfort, and full ROM should be achieved in 2-6 weeks. Therapy focuses on scapular stabilization and neuromuscular control around the shoulder, and avoids exercises that mimic the original mechanism of injury. An integrated throwing program (or other sport-specific interval program) may be started at 8-12 weeks. Return to play is permitted after demonstrating strength and ROM comparable to 90% of the unaffected side. Functional tests that indicate that return to play is appropriate include a pain-free push-up and pull-up, which usually occurs in about 12 weeks. In contrast, rehabilitation after a SLAP repair emphasizes precaution to allow proper healing of the repaired structures. The athlete is required to remain in a sling full-time for up to 4 weeks, including during sleep. Permitted ROM is limited in the first month, and progression to full function is much slower. Interval training programs may not be initiated until 16 weeks, and extend for longer periods of time. Full return to play may not be allowed for up to nine months, although advances in repair techniques have provided for increasingly short rehabilitation times. Readiness for return to sport is tested in the same manner as after debridement [2,16].

A recent study identified 51 pitchers who had pitched in at least one MLB game prior to undergoing isolated glenoid labral repair and found that 72.5% of pitchers returned to MLB at a mean of 13.1 months with no significant performance drops [17]. Starting pitchers had a higher risk of labral injury requiring repair, but pitchers with greater preoperative innings pitched per season have a greater likelihood of returning to play [17].

Conservative treatment may be considered for athletes with small injuries who require minimal overhead activity. Approach to rehabilitation is similar to that employed after debridement, and with good progression the athlete may return to full activity in 3-6 months. Accomplishments required for unrestricted play are identical to those after surgical treatment.

**Clavicle Fracture**

Associated Activities: Hockey, extreme sports, BMX, risk during most contact sports

Clavicle fractures occur commonly after a hard fall onto or a direct blow to the tip of the shoulder that compromises its structural integrity. In a study that included 65 professional cyclists, only nine (14%) were free from injury [18]. There were 21 total fractures that occurred at different locations, but the clavicle was clearly the most frequently affected bone (43%) [18]. Fractures are most common in the middle third of the clavicle, where the cortex is thinnest. Treatment is generally conservative with immobilization in a figure-eight sling until full bone healing occurs at approximately 4-6 weeks. Risk of non-union is increased with any of the following conditions: clavicle shortening of more than 15 mm, comminution, displacement, and increased age. Some types of distal clavicle fractures are also prone to non-union. Fractures at high risk of non-union are treated surgically [2,19].

During the period in which the athlete wears a sling, gentle ROM exercises should be performed to prevent stiffness. No movements should elicit pain. Return to sport is permitted after
fracture healing occurs, at about 4-6 weeks. A palpable deformity over the healed fracture site is generally expected but should not interfere with performance ability. General shoulder and arm reconditioning should be implemented, but no restrictions are necessary as long as bone healing is confirmed.

**Biceps Tendinopathy**

Associated Activity: Weight training, swimming, gymnastics

Biceps tendinopathy may be an isolated (primary) condition or be associated with another issue such as glenohumeral joint labrum problems, rotator cuff pathology or dynamic glenohumeral joint instability or laxity. Tendinopathy associated with rotator cuff problems is more common, as the rotator cuff muscles hold the biceps tendon in place and prevent it from sliding out of the bicipital groove and fraying against the humerus as it slides. In either case, the biceps tendon renders notable pain in the anterior shoulder region during resisted elbow flexion and supination, as seen during bicep curls or resisted or repetitive forearm supination.

Acute treatment involves rest, ice, and anti-inflammatory medications. Activity should be avoided until pain completely subsides. Once this occurs, gentle ROM activity should be performed. Horizontal abduction and other movements that could irritate the rotator cuff should be avoided at this time, since rotator cuff injury is very commonly seen concurrently. Treatment in this inflammatory phase should focus on pain-free exercises incorporating scapular stability/re-education activities. Due to the fact that dynamic glenohumeral joint instability is a common concurrent impairment, improving glenohumeral joint internal rotation with posterior capsule remodeling and stretching should be explored in this phase as well. Inflammation can also be reduced by steroid injection either into the biceps tendon sheath (guided by ultrasound) or into the glenohumeral joint itself which communicates with the biceps tendon sheath (guided by ultrasound or contrast enhanced fluoroscopy). Physical therapy focuses on scapular stabilization first with progression to pain free strengthening of the rotator cuff muscles.\(^2,20,21\)

As with shoulder impingement, the transition from physical therapy to full play should be bridged by a thoughtful training program, with small and steady increases in exercise intensity and duration. Posterior capsule flexibility can be preserved with integration of a low row exercise (or other biomechanically-similar variants) into the regular training regimen and specific stretching. Progression to scapular stabilization with eccentric strengthening and ballistic exercises should be introduced in a slow, graded fashion.

**Medial and Lateral Humeral Epicondylosis**

Associated Activities: Tennis, racquetball, badminton (lateral epicondylosis), baseball, golf (medial epicondylosis)

Medial and lateral humeral epicondylosis are overuse syndromes associated with the elbow. **Medial epicondylosis**, commonly referred to as “golfer’s elbow”, is associated with repetitive and forceful wrist flexion and pronation movements, as are commonly seen in golf and overhead throwing. **Lateral epicondylosis**, or “tennis elbow”, is seen with wrist extensor overuse, as occurs with backhand strokes in tennis. While frequently referred to as “epicondylitis”, these conditions are more correctly termed “epicondylitis” to reflect their degenerative rather than inflammatory

**DEFINITIONS**

**Medial epicondylosis** –

Inflammation of the epicondyle often referred to as “golfer’s elbow”; is associated with repetitive and forceful wrist flexion and pronation movements, as are commonly seen in golf and overhead throwing.

**Lateral epicondylosis** –

Inflammation of the epicondyle often referred to as “tennis elbow”; is seen with wrist extensor overuse as occurs with backhand strokes in tennis.
nature. Of interest, these issues are more common of recreational or novice athletes rather than their well-trained counterparts due to variations in proper technique [2,8,22,23].

The underlying pathophysiology of medial and lateral epicondylitis is the same, and involves repeated microtrauma to the respective tendon, with subsequent inflammatory responses. Athletes generally experience a slow onset of activity-related pain and tenderness over the origin of the wrist flexor or extensor muscle group on the medial or lateral humeral epicondyle. The pain may radiate down the forearm along the course of the associated muscle group.

As with any overuse syndrome, onset of medial or lateral epicondylitis is commonly associated with a sudden increase in activity as well as improper technique, which results in excessive strain on the associated tendons. In the case of tennis, contributing factors can include improper grip size, use of a new grip technique or racquet, or frequently hitting into the wind. Lateral epicondylitis frequently occurs outside of athletic settings in people who undergo abrupt increases in physical activity, as with weekend home improvement projects.

At the onset of the injury, rehabilitation focuses on rest and modalities to decrease pain and reactive inflammation. Gradually, exercises are added to promote flexibility, and then build strength and coordination. Eccentric exercises (wrist flexion) are initiated first, while concentric exercises are incorporated later. It is thought that aggressive eccentric strengthening likely induces microtears and resultant neovascularization [2,8,22,23]. A strengthening and stabilization program for the shoulder and scapula is often added, as optimal shoulder kinetics is an important foundation for the distal upper limb joints. The duration of acute physical therapy is typically eight weeks.

A vast array of modalities is under clinical investigation for use in both lateral and medial epicondylitis. Among the modalities which have showed mixed results are LLLT, transcutaneous electrical nerve stimulation (TENS), acupuncture, iontophoresis, and therapeutic ultrasound. Though promising in treatment of Achilles tendinopathy, ESWT is not effective for lateral epicondylitis. Counterforce bracing is commonly utilized, and provides pain relief to some athletes [2,8,22,23]. The underlying principle of counterforce bracing is that a compressive force over the wrist extensor muscles will expand the area over which stress is applied to the common extensor tendon. A deloading taping technique may similarly be used.

A number of additional treatments are currently being explored. Nitric oxide donor therapy, as delivered transcutaneously, is thought to promote collagen production but poses the risk of significant headaches and rash. Botulinum toxin may improve pain; however, it also unsurprisingly results in adverse effects on muscle function. Trials of autologous blood injection, or platelet-rich plasma, are being performed on multiple types of tendinopathy. Ultrasound-guided dry needling of the common extensor tendon has shown some promise; however, no clear benefit has been demonstrated with any of these experimental therapies. Open surgery to debride the tendinosis is offered in recalcitrant cases [2,8,22,23].

After the athlete has been discharged from therapy, a sport-specific integrated program with alternate day performance should be implemented. This transition to full activity usually occurs over 3–6 weeks, but the exact duration should be dictated by the individual rather than by a predetermined program. Modifications should be made to the athlete’s usual activities; for example, a tennis player should use foam balls or low compression tennis balls initially, and consider a racquet with lower string tension. In addition, any equipment used should be re-evaluated; golf clubs and tennis racquets should be of appropriate grip size. Importantly, the athlete should be

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**DEFINITIONS**

**Neovascularization** – The formation of functional microvascular networks with red blood cell perfusion

**Transcutaneous electrical nerve stimulation (TENS)** – The use of electric current produced by a specialized device to stimulate the nerves associated with damaged tissue for therapeutic purposes

**Platelet-rich plasma** – An autologous product derived from the patient’s blood containing plasma and a high concentration of platelets as well as various growth factors; when injected into damaged connective tissue it is believed to initiate/expedite the healing process
supervised by a skilled coach or other analyst to ensure proper biomechanics during play, with special attention to scapular mechanics and integration of the trunk and kinetic chain during the swing motion associated with the sport.

**Lumbar Disc Herniation**

Associated Activities: Risk among almost all athletes and non-athletes alike

Low back pain is a problem that occurs with extremely high frequency, both among athletes and non-athletes alike. The etiologies of the disorder are widespread and often stem from dysfunction in the kinetic chain. This is commonly due to musculoskeletal imbalances, unilateral or bilateral restriction, poor movement technique, weakness in central stabilizing segments, and excessive loading and/or overuse. In most cases low back pain is simply a factor or combination of factors associated with inadequacies in strength, stability and ROM.

One major cause of low back pain is herniation of a lumbar disc. This condition refers to protrusion of the jelly-like nucleus pulposus tissue from the center of an intervertebral disc out beyond the normal bounds of the disc. In addition to low back pain, a herniated disc may cause radiation of pins-and-needles or “electric” pain down the leg, due to irritation of or impingement on a spinal nerve root (known as radicular symptoms). Disc herniation is actually an end-stage finding in a spectrum of degenerative intervertebral disc disease, which starts with tiny tears in the annulus fibrosis, the tough outer layer of the disc. This degeneration may be particularly accelerated in athletes due to the high-force multidirectional demands commonly placed upon the spine. The athlete may be able to recall one particular event that initiated the pain, which may range from minor to severe and debilitating. Torsion (twisting) forces cause the greatest stress upon the disc, although flexion and axial compression also contribute significantly. After the initial injury, the pain may be magnified by secondary muscle spasm as well as maladaptive postures and movements adopted as compensation for the original pain. Diagnosis is confirmed by MRI [2,8,24].

When radicular symptoms or severe pain are present, initial treatment involves a short course of bed rest. The athlete should avoid sitting up, and adopt the most subjectively comfortable lying posture. This period should not last more than 48 hours, and gentle non-aggravating exercise should be initiated as soon as possible. Gentle ROM and back extension exercises are started first. Analgesics should be used for pain; muscle relaxers are frequently helpful for associated muscle spasms. Any activity that causes pain in the back or symptoms in the legs should be stopped immediately and avoided. The next goal in recovery is centralization of the pain, or absence of radicular symptoms. Once this is achieved, core strengthening exercises may be advanced more aggressively. Initially, caution should be exercised to avoid spine flexion and especially twisting. Electrotherapeutic modalities, such as TENS may be used for pain. Manual therapy may be helpful if pain is not severe, but is contraindicated if radicular symptoms are present. Dry needling of low back trigger points may be helpful in relief of discomfort due to spasm; traction and taping may also reduce pain [2,8,24].

When the athlete has demonstrated sufficient core stabilization and is pain-free, sport-specific training may be initiated. At this point, cardiovascular conditioning should be encouraged as periods of back rest are notorious for causing general deconditioning. This period is the best opportunity to correct any modifiable factors that contributed to the initial injury. Poor posture should be corrected, as well as any pathological biomechanics. Lifting technique and sport-specific actions should be analyzed carefully for movements that may predispose an
athlete to repeated injury. The athlete should also be examined for contributory inflexibility. For example, restriction in the right hip capsule through internal rotation may result in excess lumbar spine twisting; the pelvis and lower spine turn to the left relative to the upper segments in order to achieve the same movement in the right leg that would otherwise be accomplished by the hip. Core stabilization exercises should continue after the athlete has returned to full activity.

When back pain fails to respond to physical therapy, fluoroscopically guided, contrast-enhanced epidural steroid injections may be used. When problems due to disc herniation are recurrent, refractory to other treatment, or progressive, surgery may ultimately be necessary. The procedure that is generally performed for herniated discs is microdiscectomy or discectomy (removal of the bulging portion of the disc). Direction on recovery from surgery should be guided by the surgeon’s restrictions and successive follow-up evaluations [2,8,24].

The duration of the rehabilitation period varies widely and depends on many factors. Removal from competition may last a few weeks, or may (rarely) be permanent if irreversible neurologic damage is sustained. Advancement to increasing levels of therapy and training are driven by the individual athlete’s symptoms, and acceleration past these restraints should not be attempted. Premature return to play is responsible for a large portion of recurrent problems. Therapists should monitor for adverse dynamic neural tension during performance of the seated slump, straight leg raise, and/or femoral stretch assessments as applicable measures can help guide the appropriate rate of exercise progressions. If pain is present with these neural tension maneuvers, the exercise program needs to be downgraded until it resolves. Throughout the recovery process, vigilance for “red flag” symptoms is critical. All members of the athlete’s treatment team should monitor for potential signs of permanent neurologic damage, which include severe or progressive weakness, pain, and numbness, as well as new-onset bladder dysfunction.

Spondylolysis & Spondylolisthesis

Associated Activities: Gymnastics, weight lifting, football (especially lineman), diving, cricket

Spondylolysis is a stress fracture of the pars interarticularis which occurs due to repeated hyperextension of the lumbar spine. This pathology has been found to be present in 3-6% of the Caucasian population. It is seen in athletes that undergo considerable spine extension, such as in gymnastics, weight lifting, football (especially lineman), diving, and cricket. Athletes will typically complain of one-sided back pain that is worsened with back extension, especially when combined with twisting towards the affected side. When spondylolysis is bilateral, slipping of one vertebra forward relative to an adjacent vertebra may occur; this is termed spondylolisthesis. Early diagnosis and treatment of spondylolysis is important, as advanced stages rarely heal and may require surgical intervention if there is spondylolisthesis present. A defect of the pars interarticularis can be identified on x-ray; however, bone scan with Single-photon Emission Computed Tomography (SPECT) and/or MRI with Short TI Inversion Recovery (STIR) sequencing is required to ascertain whether it is a new or old issue [25].

Early treatment involves rest and complete withdrawal from athletic participation. As soon as pain remission is achieved, exercises on the abdominal muscles and back extensors should commence. Stretching and strengthening of the hamstrings and gluteals are also important, as these
muscle groups are synergistic for movements related to back extension. Horizontal side support exercises are particularly helpful, as they strengthen the core without back extension and avoid compression and shearing stresses (which exacerbate spondylolysis) on the vertebrae. A stabilizing brace may be beneficial, especially when pain is slow to abate. When initially aggravating movements no longer cause pain and back tenderness is absent, a gradual resumption of activity can be initiated. Emphasis is placed on lack of pain in movement and a sport-specific reconditioning program. The athlete should be carefully observed for regular use of predisposing movements and poses; technique errors should be corrected when identified. Methods of kinetic compensation for reduced back extension should be taught as well. Core strength and endurance exercises should be continued during and after the return to sport transition, which may last 1-2 months, however the duration is ultimately determined by the athlete’s symptoms [24,25,26,27].

When spondylolisthesis is present and symptoms involve worsening pain, numbness or weakness, surgical intervention is warranted. Failure to improve after one year of appropriate conservative treatment is also an indication for surgery. When spinal instability is identified, the treatment is posterior spinal fusion. This surgery involves connecting multiple vertebrae with plates and screws to provide stability but limit motion to the affected vertebra. If there is no instability, direct repair of the fracture may be performed. The recovery period from these surgeries is much more extensive and is guided by the surgeon. After a spinal fusion, performance may be permanently limited. Thus, surgery is reserved for the most refractory and disabling cases of spondylolisthesis [24,25,26,27].

**Sports Hernia**

Associated Activities: Soccer, hockey, football, dance

**Sports hernia** is the name given to a sport-related injury characterized by chronic groin pain. While the class of injury is fairly common it is not completely understood. A number of low abdominal and pelvic structures may be involved in the injury, and its natural history and associated clinical findings suggest that it is a syndrome of chronic overuse which may be superimposed on congenital anatomical vulnerability. Also sometimes referred to as “inguinal insufficiency” or “footballer’s hernia”, a sports hernia is most commonly associated with soccer and hockey due to their heavy use of the thigh adductors often combined with rotational stress. An athlete with a sports hernia will generally complain of a gradual onset of dull groin pain which manifests towards the end of, or after, competitive play. The pain may radiate into the thigh, testicle, or abdomen. It is worsened with coughing, sit-ups, and kicking. Nearly all athletes with sports hernias are male. Symptoms may abate for days to weeks if the athlete withdraws from sports for a longer period of time, but tend to recur when activity is resumed [2,28,29,30].

A number of mechanisms of injury for sports hernias have been proposed; most likely, the cause is multifactorial. One hypothesis states that chronic downward traction on the pubic rami and resultant shearing forces on the pubic symphysis are exerted due to significant differences in strength between the stronger thigh adductors and weaker low abdominal muscles. Other explanations include small tears, congenital weaknesses, dilation, or avulsion of a variety of low abdominal and groin soft tissues. These theories are supported by findings on MRI and during surgery. It is important to remember that there is no true hernia (a protrusion of a portion of tissue or organ through its natural boundary structures) in a sports hernia; therefore a true

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**DEFINITIONS**

**Sports hernia** – A syndrome of chronic overuse characterized by chronic groin pain and believed to be caused by a number of mechanisms including congenital anatomical vulnerability; is most commonly associated with sports that require heavy use of the thigh adductors combined with rotational stress such as soccer.
hernia should be ruled out as the cause of pain. Similarly, pubic symphysis fractures should be investigated as a potential problem before a sports hernia is diagnosed [2,28,29,30].

Conservative treatment consists of rest and modalities for pain control acutely, followed by physical therapy. Early therapy focuses on stretching, with later emphasis on strengthening of low abdominal muscles to correct abdominal to thigh adductor strength imbalances. Use of the thigh adductors is avoided during this period of time. Strengthening of the hip flexors and all core musculature is incorporated into the rehabilitation program. Sport-specific drills are eventually added, emphasizing the transverse plane. Return to sport will generally occur about 6-8 weeks after the initiation of treatment, indicated by being able to perform the aforementioned skills without pain [2].

Sports hernias have traditionally been treated with physical therapy, but the rate of recurrence is relatively high even with a suitable therapy regimen. More recently, treatment has been surgical; this is especially true of sports hernias that do not improve with rehabilitation alone. These surgeries typically consist of some form of hernia repair (despite the lack of demonstrable hernia) with the understanding that reinforcement of minutely damaged low abdominal tissues will absorb the repetitive stress upon these weakened structures [2,28,29,30]. Initial results of surgery are excellent, with athletes typically returning to competition pain-free four weeks post-operatively. The long-term success of these operations is less well-known.

Hamstring Strain

Associated Activities: High prevalence in nearly every sport; Type I injuries - football, rugby, soccer, and track and field; Type II injuries - ballet dancers and gymnasts

Hamstring strains are one of the most prevalent, and commonly recurring sports-related injuries. A group of researchers recently evaluated 51 professional soccer teams (including 2299 players from 24 different clubs) selected by the Union of European Football Association. They found that muscle injuries constituted 31% of total injuries and caused 27% of total injury-related absences [31]. The vast majority of all muscle injuries affected the four major muscle groups of the lower limbs: hamstrings (37%), adductors (23%), quadriceps (19%), and calf muscles (13%); with 16% being recurrent issues [31].

This injury involves trauma to a portion of the hamstrings, which consists of the semitendinosus, semimembranosus, and biceps femoris. These muscles originate on the posterior pelvis and femur, bridging both the hip and knee joint before inserting on the tibia and fibula. Knowledge of the anatomy and function of these muscles is important for understanding the rationale behind restrictions and rehabilitation, as well as mechanisms of re-injury. An athlete who has experienced a hamstring strain will nearly always recall an acute event, with a “pop” heard or felt in the back of the thigh followed immediately by pain. When an athlete complains of posterior thigh pain, it is important to rule out other conditions. With an acute, highly painful injury, tendon rupture should be ruled out. It is also important to consider that pain in this location may actually be referred from the lumbar spine or sacroiliac joint [2,7,8]. In addition to flexion of the knee and extension of the hip, the hamstrings are important for controlling and slowing down the lower leg in the swing phase of gait via eccentric contraction. In fact, many hamstring injuries occur during eccentric rather than concentric contractions. The hamstring also supports the structural functions of the anterior cruciate ligament (ACL) and medial collateral ligament (MCL).
Risk factors for hamstring strain include inhibited gluteal muscle recruitment, poor hamstring and quadriceps flexibility, reduced ankle dorsiflexion, and poor lower limb joint positional sense. Strength imbalances are a major issue and often are identified as a contributing factor to injury. Strength disparities between hip extension and knee flexion of the same leg, between right and left sides, as well as between agonist/antagonist muscle groups are common precursors to a strain. In addition, poor running technique and insufficient control over core and pelvic motion will also increase the risk of injury. Prior hamstring strain is another predictor, with recurrence rates of up to 30% being reported [2,32,33,34].

Recently, hamstring injuries have been classified into two types. Type I injuries, which are more common, are seen during running, especially at high speeds. Associated sports include football, rugby, soccer, and track and field. This type of injury is sustained during eccentric hamstring contraction. The degree of pain and disability seen after a Type I injury is usually greater than that of at Type II, but recovery is often quicker. Type II hamstring strain, in contrast, is characterized as more of a stretching injury and is seen in ballet dancers and gymnasts. The associated movement is an extreme hamstring stretch coupled with flexion at the hip. This injury involves the semitendinosus and its associated tendon; as with all tendons, the blood supply is less than that of a muscle and healing is consequently slower [2,32,33,34].

Immediate treatment of hamstring strain involves suppression of inflammation and pain with use of oral medications and appropriate modalities. Ice may be used immediately and should be applied every few hours. Use of NSAIDs is a topic of debate due to the possible risk of delayed recovery. Similarly, the risks of steroid injections (delayed healing, potential tendon damage) must be weighed against the benefits (decreased pain, possibly expedited return to sport). Some recent studies into models of tissue healing suggest that gentle, pain-free isometric contractions started soon after the injury may accelerate the healing process. Soft tissue mobilization techniques including the Graston Technique may be used to prevent scar tissue formation, although the benefit of this has not been clearly demonstrated. Some therapies currently being investigated include platelet-rich plasma injections as well as Traumeel S/Actovegin (an anti-inflammatory drug which can improve oxygen transport to damaged muscle tissue). However, a complete investigation has not been made into either the effectiveness or safety of these agents [2,32,33,34].

Rehabilitation also includes controlled stretching of the hamstrings and quadriceps. Areas for strengthening include the quadriceps, hip flexors, and hamstrings as well as synergistic muscles (gluteals, thigh adductors). Aggressive hamstring stretching should be avoided with Type II injuries. Strength in the core and pelvic stabilizers is developed as an important foundation for proper walking and running biomechanics. Cautious advancements should be made in therapy intensity during the first week of recovery, when early symptomatic improvement without full tissue healing leads to an increased risk of re-injury. Pain-free walking can be progressed to jogging, then sprinting. An interval running program may be implemented; running should take place every other day to allow muscle recovery and make appropriate adjustments to training intensity based on symptoms. Any individual-specific risk factors, such as right-left strength or joint-to-joint discrepancies should be identified and addressed.

Unrestricted return to sport after a first-time injury typically occurs in 1-4 weeks, although
the release to play is dependent on the individual athlete’s benchmarks rather than a fixed schedule. Positive prognostic indicators include pain-free walking within 1 day of injury, no lesion on MRI, Type I injury, and no prior hamstring injury. As with many other injuries, prerequisites for return to play include strength, power, and endurance that are 90% of the contralateral side [2,7,8,32,33,34]. Flexibility should be equal on right and left sides, and there should be no pain with activity. Functional tests should demonstrate the ability to side step as well as quickly change pace and direction without difficulty or discomfort.

**Patellar Tendinopathy**

Associated Activities: Jumping sports including basketball, volleyball, track and field

Patellar tendinopathy, commonly called “jumper’s knee”, refers to an overuse injury to the patellar tendon, with accumulation of microtrauma due to repetitive jumping or rapid changes in direction. The most commonly involved site is the inferior pole of the patella. The athlete will present with a gradual onset of anterior knee pain during jumping and other acceleration-deceleration activities. Pain may be localized to the bottom-most portion of the patella. Aside from the above aggravating activities, risk factors include increasing age, playing on hard surfaces, decreased ankle dorsiflexion, incorrect loading mechanics (e.g., tibial translation) and weakness or tightness within the surrounding musculature (e.g., quadriceps, calf, and gluteus). In taller athletes mechanical issues may also increase risk [2,4].

The rehabilitation period for patellar tendinopathy is relatively long, lasting up to one year in athletes who have had multiple recurrences. Rehabilitation centers on tendon unloading strategies. As with other overuse injuries, relative rest is an important component of recovery; however, absolute rest can result in a weakened tendon as well, and should be avoided. Range of motion exercises should emphasize flexibility in ankle dorsiflexion as well as in the hamstrings, quadriceps and calves. Eccentric strengthening exercises are vital, and exercises such as squats are often performed on a decline board (as though the athlete is on a downhill slope). Biomechanics at the hips, knees, and ankles should be analyzed to identify opportunities for patellar tendon unloading modifications. In particular, ankle and calf movements can absorb significant amounts of force that would otherwise be transmitted to the knee. For example, landing from a jump on the forefoot with increased flexion of the knees and hips will redistribute weight and tension favorably for the patellar tendon. Physical therapy may be mildly painful, but this is acceptable under the guidance of an experienced therapist. When returning to training and competition, however, the athlete should be pain-free.

No modalities have shown compelling evidence of efficacy for patellar tendinopathy. Sclerosing injections may be useful for reducing pain. Steroid injections also decrease pain in the short-term, but they ultimately slow recovery. Soft tissue therapy, such as transverse friction massage, is not beneficial. There is insufficient evidence concerning platelet-rich plasma injections and prolotherapy, both in efficacy and in safety.

Return to full performance should not be accelerated, given the high rate of recurrence and slow recovery rate from patellar tendinopathy. Training should emphasize muscle balance at the knee particularly between the vastus medialis and the vastus lateralis to promote patellar tracking. Likewise, the gluteals should be activated effectively to reduce knee stress. Impact activities...
should be carefully monitored, and the inclusion of impact landing activities should be slow and gradual. Rehabilitation and guided strength training should continue even after the athlete has returned to play. Plyometrics, speed and power training is generally not incorporated into the rehabilitation continuum until at least 3 months after the initiation of the treatment program. Above all, the athlete should be monitored for symptoms indicating that the rate of training intensity is increasing too rapidly, or that biomechanics require re-assessment. Athletes may wear a prophylactic device such as a neoprene sleeve to promote optimal temperature and blood flow during training and play \[2,8\].

**Patellofemoral Syndrome**

Associated Activities: Running, soccer, basketball, football, martial arts

Patellofemoral syndrome, or patellofemoral pain, is a term that encompasses knee pain that may be due to a wide variety of problems. It is one of the most common musculoskeletal complaints among athletes and the general population alike. The common unifying characteristic of patellofemoral pain is pain associated with pressure of the patella upon the femur; the athlete will give a history of pain and discomfort with squats, downhill activity, climbing stairs, and any other weight-bearing activity with a deeply-flexed knee. The pain is generally slow in onset and described as a deep, dull pain that may be located to the anterior knee or posterior to the patella.

There are a significant number of dynamic and static factors that may contribute to patellofemoral syndrome. These include excessive femoral internal rotation, knee valgus, tibial rotation, subtalar pronation, and increased tightness of the muscles and soft tissues around the knee. One of the most commonly observed problems is an imbalance between the medial (vastus medialis obliquus, or VMO) and lateral (vastus lateralis) aspects of the quadriceps. The VMO is often found to be weaker or slower to activate than the vastus lateralis, which results in the patella being pulled laterally during flexion and extension. Rather than tracking centrally in the groove of the femur, the patella grinds laterally against the femur, causing tissue irritation and discomfort. This lateral tracking of the patella may be augmented by increased tightness in the lateral soft tissues around the knee. A high degree of knee valgus, or increased Q angle (quadriceps angle), is also an important component in patellofemoral pain. There may be structural factors involved (such as a wide pelvis), but many underlying problems are functional; among these are weak gluteal muscles and excessive pronation at the subtalar joint as mentioned previously. Similarly, femoral internal rotation may be structural or related to hip muscle weakness \[2,8\].

Rehabilitation must be tailored towards correcting the biomechanics specific to each athlete. Immediate pain relief can be achieved with ice, over-the-counter pain medications, and patellar taping. Isolated strengthening of the VMO is difficult, but its utilization during exercise may be monitored using a biofeedback unit. To avoid excessive patellofemoral compression, initial exercises should avoid deep knee bending and include straight leg raises and forty degree mini-squats. Femoral internal rotation should be corrected with gluteal strengthening, and inadequate flexibility should be addressed at the quadriceps, hamstrings, calves, and tensor fascia latae. Strengthening of the core is also beneficial given the relationship between core strength and pelvic and hip stability.

Patellar taping is of particular benefit in patellofemoral pain associated with abnormal patellar movements. The general principle of taping is to stabilize the patella against painful
excessive movement, and can be implemented as soon as pain is identified. Taping should be employed during early to intermediate rehabilitation before patellar stabilization function is taken over by retrained muscles. Effective tape placement and technique can be identified by immediate alleviation of knee pain with previously painful activity. Many patella stabilization braces are also commercially available, but tend to be less effective, most likely because they do not specifically address the athlete’s particular direction of patellar movement. If excessively tight soft tissues are an issue, tissue mobilization is beneficial. Modalities such as warm whirlpool bath may be used prior to manual mobilization. Excessive pronation can be addressed with changes in footwear and use of orthotics. If a true leg length discrepancy is a contributor, an orthotic with heel lift should be implemented.

Progressive return to play is guided by absence of pain as well as objective demonstration of appropriate flexibility, strength, and functional ROM. Sequenced unilateral deceleration drills can be used effectively to emphasize correct biomechanics. It is important to ensure that equal strength exists in all major muscle groups of the hip, knee, and ankle on both the affected and unaffected sides. Unless musculoskeletal structures with known damage are present, an athlete with corrected biomechanics and no pain can undergo a prescribed incremental return to full activity.

Anterior Cruciate Ligament Tears

Associated Activities: Sports that require frequent pivoting and sudden deceleration including football, basketball, soccer

One of the most dreaded sports injuries is a tear of the ACL. This ligament in the knee attaches on the posterior femur and the anterior tibia, and prevents anterior translation of the tibia relative to the femur. Tears to the ligament are common in sports that require frequent pivoting and sudden deceleration, such as football, basketball and soccer. The mechanism of injury of an ACL tear is most frequently non-contact, and involves a combination of valgus and torsion stresses on the knee. An athlete will typically be undergoing a cutting maneuver or other pivoting movement and hear a “pop”. Immediate pain is usually sufficient to prevent further play or even walking off the field. Swelling is seen soon afterwards due to bleeding into the joint. ACL tears are rarely seen in isolation; the most usual concurrent injuries are medial collateral ligament (MCL) tears and meniscal tears [35,36].

Unfortunately, very little compelling evidence is available to guide current practice as to the treatment and rehabilitation of ACL tears. Complete ACL ruptures are treated with surgical reconstruction, but recent evidence suggests that surgery and conservative treatment may be equally effective for partial tears without any significant difference in recovery time. However, tears initially treated with therapy alone may require surgery at a later date. If surgery is postponed, adequate strength preparations should be made prior to surgery to offset post surgery decline in strength and mass. After the acute inflammatory phase has ended, sensations of instability or episodes of the knee “giving out” are common reasons for surgery to be performed. In general, young and active athletes undergo reconstruction, especially those competing at an elite level.

Rehabilitation should be initiated immediately after the injury, whether or not the athlete will undergo surgery. Immediate treatment involves PRICE, NSAIDs, and early passive ROM. Pain-free partial weight bearing with crutches is permitted. As inflammation subsides and ROM is re-established, physical therapy focuses on neuromuscular control and proprioception as
related to the knee. Concurrent injuries must also be addressed when developing a therapy program. Loaded knee extension should be avoided, as these place particular stress on the ACL. Plyometric exercises are becoming an increasingly important component of rehabilitation, as is **perturbation training**. Perturbation training involves the use of equipment with variable levels of stability, such as rolling platforms and tilt boards; these exercises are designed to increase the athlete’s ability to quickly respond to destabilizing positions and movements by adopting more stable stances. Core stabilization programs are also being incorporated with increasing frequency into ACL rehabilitation. The athlete must be educated on vigilance concerning symptoms after therapy, as this is the greatest indicator of whether current therapy is too aggressive, or if advances in difficulty are appropriate\[35\].

Modalities used for ACL rehabilitation include TENS with therapeutic ultrasound and manual therapy. A number of treatments are under investigation for acceleration of recovery from ACL tears, the most prominent of which are platelet-rich plasma and collagen-fibrin scaffolds (supporting structures made of collagen fibers inserted around the site of damage), but current data is insufficient to conclusively justify their use in practice\[35\].

Special consideration may be warranted for female athletes, who are 2-9 times more likely to injure an ACL than their male counterparts\[2,7,8\]. The discrepancy in risk is attributed to a variety of structural, molecular, and neuromuscular sex differences. One clearly identified neuromuscular factor is “quadriceps dominance”, in which women activate their quadriceps in response to an anterior translation force on the tibia sooner than they activate their hamstrings. Since the hamstring stabilizes the ACL and the quadriceps places additional force onto the ligament, risk for injury is increased. Recognition and intervention with physical therapy regarding neuromuscular differences may decrease the risk of injury.

Return to sport typically occurs between 6 and 12 months post-injury, although this decision must always be made for an athlete based on individual milestone achievements. Some accelerated rehabilitation programs may permit full activity as soon as 4 months post-injury. Many functional tests are available to indicate return to play, including vertical jump tests, sport-specific drills, and adequate tolerance of plyometric exercises. A common functional strength test is the single leg squat. The athlete’s confidence in the stability of the injured knee is an important prerequisite for return to play.

**Lateral and Medial Collateral Ligament Sprain**

Associated Activities: Football, basketball, soccer, rugby, hockey

The lateral and medial collateral ligaments are major stabilizers of the knee against varus and valgus stress, respectively. Tears of the medial collateral ligament (MCL) are much more common, and may be due to contact or non-contact mechanisms that exert excessive valgus force on the knee (force directed on the knee from lateral to medial). Due to the role of the collateral ligaments in controlling rotation of the tibia relative to the femur, a sprain may also be caused by forceful rotation at the knee, which would likely result in more than one damaged knee structure. Injuries to the MCL are commonly seen in concurrence with ACL injuries, and sometimes with medial meniscus tears. Lateral collateral ligament (LCL) sprains are associated with posterior cruciate ligament injuries. Athletes with MCL or LCL sprains will experience a delayed onset of pain and swelling at the medial or lateral aspect of the knee following
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the trauma. Increased varus or valgus laxity as well as a sense of general instability may also be present \[^{2,7,8}\].

Medial collateral ligament sprains are graded from I through III, based on their severity. A grade I sprain presents with pain but no instability, whereas a grade III sprain indicates a complete tear. Grade I and grade II sprains are treated conservatively with supportive bracing, and immediate partial weight bearing activity can be performed as long as it is pain-free. The brace is worn for decreasing periods of time based on improvements in knee stability and pain. Grade III sprains may be treated surgically, but conservative treatment is also effective. The athlete is restricted from any weight bearing for approximately 2 weeks. Stricter protective bracing is implemented, with a locking hinge to limit ROM for up to 6 weeks \[^{2,7,8}\].

Physical therapy focuses on strengthening and neuromuscular control of the quadriceps, hamstrings, and hip abductors and extensors. Progression of exercise difficulty may be relatively aggressive and is based primarily on the athlete’s symptoms. Exercises that place stress on the MCL, such as resisted hip adduction with tension placed below the knee, should be avoided. The transition to full activity is bridged by development and demonstration of sport-specific skills including transverse and frontal plane motions, and the athlete typically resumes sport participation at 4-8 weeks post-injury for grade I or II tears. Grade III tears may require 3-6 months of rehabilitation and supportive training before competition can be safely resumed. In order to play, the athlete must have a complete lack of pain with any normal movement, full ROM at the knee, no instability, minimal or no valgus laxity, and ability to carry out athletic and daily activity without difficulty. A small degree of permanent valgus laxity may be seen after a grade III sprain, but resumption of play is generally safe as long as no symptomatic instability is present \[^{2,7,8}\].

Lateral collateral ligament sprains are far rarer than MCL sprains. They are graded in the same manner. However, treatment is generally surgical as combined injuries are common and do not respond well to conservative treatment. Post-operatively, guidelines for physical therapy and return to athletics are similar to that of MCL tears.

**Meniscal Tears**

Associated Activities: Jumping, landing into a directional change, pivoting with body contact

A very common traumatic injury to the knee is a tear of the medial or lateral meniscus. The menisci are two C-shaped fibrocartilage structures on the tibial portion of the knee joint, which are critical to load distribution, force transmission, and shock absorption in the knee. The classic mechanism of injury for a traumatic meniscal tear is compression and twisting of the knee, with the foot planted on the ground. This injury is commonly seen with other problems, especially ACL and MCL tears. Unlike other forms of knee trauma, pain and joint effusion may not develop with meniscal tears until hours after the initial event. Athletes may complain of “locking” which prevents full ROM as well as clicking and pain with deep knee flexion.

Treatment may involve surgical removal (meniscectomy) or repair of the damaged meniscus portion, or physical therapy alone. Non-surgical conservative treatment is essentially identical to rehabilitation after partial meniscectomy, while the physical therapy after a repair requires greater precautions and a longer recovery time. The pace and approach of rehabilitation, as with...
all sports injuries, is modified appropriately with consideration for severity and the type of tear, concurrent damage on other structures, and the individual athlete’s achievement of specific functional benchmarks. When conservatively treating meniscal tears, full weight bearing can be initiated without crutches. Knee flexion past 60° should be avoided initially. Exercises should aim to maximize ROM and strengthen the quadriceps. More advanced therapy focuses on endurance, flexibility, and proprioception exercises. Sport-specific drills are commenced at around 2-4 weeks, as long as there is no pain with any exercise. Duration, speed, and other measures of exercise intensity are slowly increased during this phase of rehabilitation. The athlete should be closely monitored for delayed pain and swelling after exercises, which indicates that the intensity of therapy should be temporarily decreased. Return to full participation in sport is permitted at 3-8 weeks after the injury, when the athlete is able to demonstrate measures of endurance, strength, and flexibility that are at least 85% of the unaffected side, particularly in the quadriceps. Another important marker of readiness for competitive play is pain-free performance in sport-specific drills without recurrent knee swelling [2,7,8].

Early rehabilitation after meniscal repair must emphasize protection of the repaired tissue. Athletes who undergo this procedure are placed in a knee brace that is locked in extension to prevent excessive shearing forces on the vulnerable meniscus. Weight bearing is limited during this protection phase, which lasts 4 weeks. The principles of rehabilitation under non-operative circumstances can also be applied after this initial protected period, but progressive challenges to the knee are introduced at a much slower rate and resumption to unrestricted play typically does not occur for 4-6 months.

Vigilance in identifying delayed symptoms is critical when working with athletes who have meniscal tears. The athlete may be able to compete at full capacity for one day without any restricting symptoms, but experiences a significant degree of delayed pain and joint effusion if the advancement in activity level was too great. Inappropriately accelerated rehabilitation can lead to chronic or recurrent problems with pain and effusion.

**Medial Tibial Stress Syndrome**

Associated Activities: Basketball, gymnastics, running

Medial tibial stress syndrome (MTSS), sometimes referred to as “shin splints”, is a term used to describe a condition with pain in the posterior-medial tibia. The underlying mechanism of the syndrome has not been clearly identified; current hypotheses include traction-induced microtrauma at calf muscle attachments and insufficient bone regeneration in the affected region of the tibia. Athletes commonly experience a slow onset of pain in the posterior-medial tibia, approximately 1/3 of the way between the foot and knee. The pain tends to diminish with warm-up exercises, but worsen after training and on the following day. Although MTSS is not fully understood, some identified risk factors include excessive pronation of the midfoot (in particular navicular drop), female gender, and higher body mass index. Other factors that are likely to contribute include a large range of hip rotation, inappropriate footwear, and sudden increases in intensity of training or varied terrain. Often, a bone scan and/or MRI are used to rule out a tibial stress fracture, which is a diagnosis that would force a longer period of rest and cross training [40,41,42].

Little evidence exists to support any specific treatment programs for MTSS. Rehabilitation focuses on addressing pain and a graduated return to play. Among the methods to reduce pain
(i.e., ice, stretching, heat, NSAIDs), those that are effective for the individual athlete should be utilized. Some athletes may also find that soft tissue techniques alleviate their symptoms. One of the few existing studies on treatment suggests that complete avoidance of the inciting activity until pain is absent may be most helpful. Work on proprioception and stretching in physical therapy may also be beneficial, as well as stretching and strengthening of the calf musculature. Emphasis is placed on eccentric strengthening of the posterior tibialis, soleus, and gastrocnemius. No definitive evidence supports the use of electrical stimulation, therapeutic ultrasound, prolotherapy, platelet-rich plasma injections, LLLT, or acupuncture [38,39,40,41,42].

Resumption of full activity should be incremental, gradual, and pain-free. Proper shoe wear and fitting that supports the foot type may prevent the need for any inserts or orthotic devices. Orthotics with good shock absorption in the insoles may be beneficial, as well as taping or orthotics to control midfoot pronation. For highly-competitive athletes with rigorous training schedules, implementation of one session of low-impact cross-training per microcycle, such as running in the pool with a flotation device, should be considered.

**Achilles Tendinopathy**

**Associated Activities:** Running, jumping

More accurately named Achilles tendinosis, this condition is mainly a degenerative or overuse disorder of the Achilles tendon with associated secondary inflammation. It usually appears at one of the following two discrete sites: over the posterior heel where the tendon inserts onto the bone (insertional Achilles tendinitis), or on the back of the ankle approximately five centimeters above the tendinous insertion (non-insertional Achilles tendonitis). Non-insertional Achilles tendonitis occurs at the "watershed zone", a region of relatively poor blood supply which increases the likelihood of poor healing in that area [2,8,43,44].

The injury manifests as a tender swelling, with or without redness at one of these two sites. The athlete will complain of dull or aching pain associated with activity which is alleviated with rest. Risk factors for Achilles tendonopathy include high arches, short heel cords, and short/weak ankle plantar flexors and dorsiflexors. Increased risk is associated with running on hard surfaces, wearing improper footwear, and training errors such as a sudden increase in duration or intensity of running. If left untreated it can often lead to missed competition; in rare cases it can progress to tendon rupture.

Acute rehabilitation includes PRICE and NSAIDs, which both alleviate symptoms and prevent the formation of weak, enlarged scar tissue. In this immediate period, physical therapy focuses on gentle ROM exercises as well as strengthening of synergistic muscle groups, such as trunk, hip, and knee extensors. Orthotics may be prescribed to correct stance abnormalities, such as over-pronation, that might be promoting excess structural stress. Modalities include heat prior to and ice following physical therapy, as well as friction massage. Steroid injections are no longer used, as there have been some cases reported of subsequent tendon rupture. Several adjunct modalities currently under investigation show promising results in accelerating the recovery process; these include low energy ESWT as well as LLLT. Platelet-rich plasma and other autologous blood injections have been proposed as an innovative treatment, but convincing clinical outcomes are yet to be published [2,8,43,44].
As the tendon begins to heal, therapy centers on restoring talocrural and subtalar joint motion and gradual strengthening of the gastrocnemius-soleus complex through eccentric exercise. These therapeutic measures will generally last 8-12 weeks. Proprioceptive training for the ankle may be performed with increasing degrees of weight bearing. Other exercises with reduced weight bearing stress, such as use of a stationary bicycle, may also be employed during this period.

After the athlete has been discharged from therapy, precautions to avoid re-injury through overtraining must be implemented. Pain is a contraindication to any exercise, although mild discomfort during training is acceptable. Orthotics and taping may be used to support the joint as previously mentioned; heel lifts and medial rear foot posts are often used. Inclines and uneven ground should be avoided initially, but increasingly challenging terrain may be slowly introduced to emphasize eccentric strengthening. Before re-entry to sport, pain-free performance and recovery from plyometric exercise should be demonstrated. Mileage, speed, and frequency of training should be increased by no more than 5% per week.^{2,8,40,44}

**Ankle Sprain**

Associated Activities: Relatively common in most team-based sports that involve lateral movement

One of the most frequent acute injuries to the lower extremity is an ankle sprain. Though commonly thought of as one joint, the ankle is a complex structure with three true joints: the talocrural, inferior tibiofibular, and subtalar. The ankle complex includes a series of ligaments, tendons, and muscles that allow both multi-planar mobility and stabilization of the body’s weight and position. The ligament that possesses greatest vulnerability to sprain is the anterior talofibular ligament (ATFL); being the weakest of the lateral ankle ligaments. The ATFL is affected in approximately 70% of ankle sprains. Sports that require a high degree of lateral movement and changing of direction pose the greatest risk. ATFL sprains generally occur when the ankle is forced into a high degree of inversion with or without plantar flexion. Athletes who sustain ankle sprains may be able to walk or even continue playing immediately after the injury, especially if it is mild in severity. However, pain and swelling occur soon afterward, and also with resumption of activity. Pain and tenderness will be greatest over the site of the affected tissue. It is important to remember the potential for coexisting injuries, such as ankle dislocation or longitudinal tendon rupture, which may be overlooked once the ankle sprain is located.^[2,8]

Ankle sprains, like knee sprains, are categorized as grades I through III, based on severity. Grade I, or mild sprains, show no abnormal or asymmetrical ligament laxity, while grade III sprains represent significant damage to the ligament. All grades of ankle sprain are treated conservatively with the same general rehabilitation principles. Grade III sprains rarely improve and subsequently require surgery. The only significant difference between treatment of the different grades is the time to full recovery.

Treatment within the first 48 hours of injury consists of PRICE. Partial weight bearing is permitted as long as it is pain-free, and crutches may be used as needed. Activities that promote blood flow to the ankle, such as hot showers and walking, should be minimized. After this early period, ROM exercises are performed as tolerated and increasing amounts of body weight may be placed on the ankle as long as no pain occurs. Braces should be used to stabilize the joint. Relatively aggressive advancements in the intensity of physical therapy can be made, as long as
nothing causes pain during or after the sessions. As symptoms permit, strengthening of the ankle musculature can commence. Special emphasis should be made on exercises for ankle eversion while the foot is in plantar flexion. Proprioception training is particularly important to avoid re-injury as mechanoreceptors may become dysfunctional in the area. Exercises used to improve proprioception include tilt boards and one-leg exercises on a mini-trampoline (or stability disc) to promote the peripheral-central feedback loop which allows for restoration of protective functions.

Splints and taping are commonly used to stabilize the ankle as the athlete begins to undertake increasing levels of activity. However, neuromuscular control training has been shown to result in the same degree of stability and injury prevention. These exercises may take up to 3 months to be fully effective in preventing re-injury; during which time taping or bracing should be used as an adjunct until full function is restored. If the athlete does not undergo this training, vulnerability to re-injury and thus the period in which taping is necessary may last approximately one year. The cost of taping may make lace-up bracing a more preferred option [2,8].

Sport-specific drills can be incorporated into rehabilitation when sufficient ROM, strength, and proprioception are demonstrated. Pain-free execution of the skills necessary for the athlete’s sport is the primary indication that the athlete may return to high-intensity training as well as competition, although continuation of neuromuscular control exercises and use of a sport-specific integrated program is beneficial for safe reconditioning of the athlete. Return to play typically occurs within two weeks of a grade I sprain, while grade III sprains may prevent return to sport for 3-4 months.

Plantar Fasciitis

Associated Activities: Running, dance

**Plantar fasciitis** is an overuse condition commonly responsible for foot and heel pain among running athletes. Also referred to as “heel spurs”, plantar fasciitis occurs due to repetitive microtrauma and undue stress exerted on the plantar fascia, which runs on the bottom of the foot and supports the longitudinal arch. As with other degenerative connective tissue injuries, the repetitive strain on the structure results in secondary inflammation. Over time, the inflammation leads to calcification of the plantar fascia at its origin on the inferior medial aspect of the calcaneus; the inferior calcaneal “spur” seen on x-ray imaging [2,8,45].

An athlete with plantar fasciitis will experience an insidious onset of pain on the inferior medial portion of the heel which may radiate out across the bottom of the foot. Often it is most painful with the first few steps in the morning and improves with continued walking. The pain worsens after intense activity. Both high arches and flat feet predispose athletes to this condition, as does excessive pronation. Other contributing factors include restricted subtalar and talocalcaneal joint motion, tight hip flexors, gastrocnemius, soleus, and/or hamstrings, as well as weak gluteus muscles. It is important to rule out other concomitant disorders including posterior tibialis dysfunction/weakness, L5-S1 radiculopathy, and medial calcaneal sensory neuropathy [2,8,45].

Initial rehabilitation focuses on controlling pain and inflammation via rest, ice, and anti-inflammatory medications. Management of athletes with high-arched cavus feet and those with flat pes planus feet differ somewhat. Therapy for the high-arched athlete focuses on stretching;
emphasis is placed on the plantar fascia as well as the calves, hamstrings, and mobility of the big toe. Mobilizing restricted subtalar joint and mid-foot mechanics can be helpful. If mobilization fails to help, then focus shifts to provide cushioning to the foot. Orthotics for high arches focus on arch support and heel cushioning to redistribute force to other portions of the foot. In contrast, the basis of therapy for the flat-footed athlete is strength and stability. Exercises are designed to strengthen the muscles that act on the foot and ankle. In contrast to the cavus foot, orthotics for the pes planus foot are constructed to prevent over-pronation and “bring the ground up to support the foot”. Strength imbalances in any leg or hip muscle group, as well as improper technique, should also be addressed.

Modalities that may be helpful include manual therapy, ESWT, and night splints. Taping techniques are used to unload the plantar fascia and control pronation. Some evidence demonstrates benefit with steroid iontophoresis, for immediate pain reduction only. Though steroid injections are commonly implemented, they should be administered cautiously; while providing good short-term relief, as mentioned earlier, they may slow healing and have been associated with plantar fat pad atrophy and in rare instances, fascia rupture. Limited preliminary trials of botulinum toxin injection have showed some promise, while autologous blood injections have not shown the magnitude of pain relief demonstrated by steroid injection. ESWT is currently used for chronic, refractory plantar fasciitis. Open surgery is only considered for completely noncompliant cases [2,4,45].

Starting treatment within 6 weeks of symptom onset has been shown to result in quicker recovery. The athlete may resume gentle, pain-free activity after the acute inflammatory phase has ended. These activities should incorporate appropriate orthoses and training should include continued stretching and strengthening as prescribed during therapy. While no clear guidelines exist on timing of return to full-intensity competition or training, the transition should be performed in measured increments. The athlete should continue to demonstrate flexibility and strength at least as great as those measured upon discharge from acute rehabilitation, and activity should be pain-free.

**Stress Fractures**

Associated Activities: Track and field, dancing, gymnastics, marching, tennis, basketball, football

**Stress fractures** occur when the fatigue damage inflicted on bones during athletic activity outpaces the bone’s remodeling capacity. Different locations are commonly associated with specific sports. For example, metatarsal stress fractures are most commonly seen with runners and ballet dancers. While fractures in the weight-bearing bones are far more common, upper extremity stress fractures can occur with throwing and racquet sports. Even though the most frequently injured bone is the tibia, the location site of a stress fracture varies by sport. Tennis, volleyball, soccer, and basketball players as well as distance runners have a higher incidence of stress fractures in long bones while sprinters, hurdlers, jumpers, gymnasts, and skaters more often experience stress fractures in the feet [46]. There are sports associated with a greater prevalence of stress fractures in the upper body as well. Rowers have a higher risk for rib stress fractures, and throwers have a higher risk for humeral and forearm stress fractures [46].

**Definitions**

**Stress fractures** – Occur when the fatigue damage inflicted on bones during athletic activity outpaces the bone’s remodeling capacity, common with low bone health

For plantar fasciitis starting treatment within 6 weeks of symptom onset has been shown to result in quicker recovery. The athlete may resume gentle, pain-free activity after the acute inflammatory phase has ended.

Stress fractures occur due to accumulated damage, athletes will report a slow onset of dull pain which is usually well-localized.
Because these fractures occur due to accumulated damage, athletes will report a slow onset of dull pain which is usually well-localized. The primary cause of stress fractures is either an absolute excess of activity or a relative increase from prior level of activity. Leg, knee, and foot alignment may increase risk by leading to areas of stress concentration in the bone or muscle when it is fatigued \(^{[46]}\). Leg-length discrepancy was found to increase the risk of stress fracture in female track and field athletes \(^{[46]}\). Another important factor is insufficient energy intake relative to expenditure; screening for disordered eating should be considered. Other potential underlying issues include poor biomechanics, limb discrepancy, improper footwear, and hard training surfaces. For acute stress fractures, x-rays are insufficient for proper diagnosis 75% of the time; suspicion for this injury warrants advanced diagnostic imaging such as MRI or bone scan \(^{[2,7,8]}\).

Stress fractures are typically categorized as high risk or low risk. High-risk fractures are those that tend to recur, progress to complete fracture, and require surgery if they are not aggressively treated. These fractures also tend to take longer to heal. Low-risk stress fractures, in contrast, can be treated in a manner more permissive of activity, and tend to heal more rapidly without complications.

The most common bones affected by stress fractures include the tibia (as mentioned earlier), the metatarsals, and the femoral neck. The two most frequent sites of injury of the tibia are the mid-anterior cortex and the medial portion. While medial tibial stress fractures are low risk, anterior cortex fractures with a horizontal “dreaded black line” on x-ray are high risk and treated surgically. Similarly, stress fractures of the metatarsals are frequently seen, often with dorsal foot swelling with concomitant dorsal metatarsal tenderness. All are considered low risk except for those of the 5th metatarsal (pinky toe). Femoral neck stress fractures are divided into compression side (inferomedial) and traction side (superolateral) \(^{[2,7,8,46,47]}\). Compression side femoral neck stress fractures heal with rest; traction side femoral neck stress fractures may need surgical care.

Low-risk stress fractures are treated with 4-6 weeks of rest. A pneumatic brace may be used for 1-2 weeks, and crutches are sometimes prescribed to completely avoid weight-bearing. After the treating physician has determined the athlete as clinically healed, training activity may begin. Integrated training programs are used to gradually increase the amount and intensity of activity. Though ultimately guided by pain-free activity, the typical training program after a stress fracture lasts 4-8 weeks. An interval running program could begin with 30 minutes of walking every third day with cross-training on the remaining days, then progress to light jogging. Over the ensuing weeks, running frequency could be increased to every other day, with full-speed running slowly added back to the training regimen. During this time, other risk factors should be addressed and corrected as needed.

High-risk stress fractures, in contrast, must be closely monitored in the acute treatment period. Pneumatic braces are more commonly implemented, and bone stimulators may be applied. However, evidence for both electrical and ultrasonic bone stimulators remains insufficient to justify regular use in clinical practice \(^{[46,47]}\). Surgical repair may be employed after 6 months without healing, while some athletes have been managed with use of a pneumatic brace for over a year. After healing has been demonstrated, an interval program similar to that used for low-risk stress fracture may be implemented. However, a longer duration and slower progression of intensity is advised, given the risk of recurrence at the same location.
REFERENCES:


