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Osteopathic approach to injuries of the overhead thrower's shoulder

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Abstract: Overhead sports place a significant amount of stress on the shoulder. There are a variety of activities and sports with overhead athletes including both throwing (baseball, softball, football, cricket) and nonthrowing (tennis, swimming, volleyball) sports. Although all of these overhead motions can lead to pathology, a large focus has been on the consequences of overhead throwing. Overhead-throwing sports place forces on the joints, muscles, tendons, and ligaments that vary through the spectrum of athletes, as does the potential injuries that may be caused by these forces. The primary joints that are commonly injured in overhead sports are the shoulder and the elbow. The goal of this article is to discuss the impact of overhead motions on the shoulder, with a primary focus on throwing, as well as to highlight the osteopathic approach to assessment, treatment, management, and prevention.

Keywords: osteopathic medicine; overhead athlete; shoulder; sports medicine; throwing injury

Overhead sports place a significant amount of stress on the shoulder. There are a variety of activities and sports with overhead athletes including both throwing (baseball, softball, football, cricket) and nonthrowing (tennis, swimming, volleyball) sports. Although all of these overhead motions can lead to pathology, a large focus has been on the consequences of overhead throwing.

The activity of throwing is a complex task that requires the coordinated effort of the upper and lower extremities as well as the trunk. During overhead activities such as throwing, forces are transmitted through the kinetic chain that influences the kinematics at the shoulder. Injuries can occur as a result of a number of reasons, with modifiable internal and external risk factors. The majority of injuries to the overhead-throwing athlete occur in the upper extremities and in particular the shoulder and elbow.

Overhead-throwing sports are played by people of many ages ranging from youth to adult athletes. The forces placed on the joints, muscles, tendons, and ligaments vary through the spectrum of athletes as do the potential injuries that may be caused by these forces. One of the primary differences between youth, adolescent, and adult athletes is the vulnerability of the open growth plate to both repetitive overuse and acute injuries. The forces and angular velocities applied to the growth plate during the early playing days may lead to structural variances and future injuries [1]. The stresses to the growth plate can also have future consequences and lead to other injuries after the growth plates have closed [1].

In addition to the differences in the anatomy due to the growth plates, there may be muscular imbalances, scapular dysfunction, or dyskinesis that may cause excessive loads of a structure and increase the risk of future injuries [2]. One of the major consequences of these changes may cause a reduction in internal range rotation and total arc of motion (TRM) of the dominant throwing shoulder, which may cause a cyclic effect of additional imbalances and tightness of the muscles of the shoulder [3].

The goal of this article is to discuss the impact of overhead motions on the shoulder, with a primary focus on throwing, as well as highlight the osteopathic approach to assessment, treatment, management, and prevention.

Shoulder anatomy

The shoulder is a complex anatomical structure that is comprised of multiple bones, joints, muscles, tendons, and ligaments. The bones that make up the shoulder are the humerus, scapula, and the clavicle. The shoulder has three bony (glenohumeral, acromioclavicular, sternoclavicular)

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articulations and one soft tissue articulation (scapulothoracic). The glenohumeral articulation is stabilized with the labral complex, which is a cartilaginous structure that extends from the glenoid and encapsulates the humeral head. The primary shoulder muscles are the deltoid and the four muscles that make up the rotator cuff (supraspinatus, infraspinatus, subscapularis, and teres minor). There are also multiple secondary muscles that contribute to the motion of the shoulder and scapular stabilization such as the biceps brachii, triceps, latissimus dorsi, trapezius, rhomboids, and levator scapula. Each of these primary and secondary muscles have tendons with origins and insertions that are prone to potential traumatic or overuse injuries. Additionally, there are five general bursa (subacromial-subdeltoid, supra-acromial, subscapular, subcoracoid, and coracoclavicular) that help protect the muscles and tendons from injury from adjacent bony prominences [4].

Shoulder biomechanics of throwing

The biomechanics of throwing can be broken down into four to six phases (football vs. baseball) that require the coordinated effort of the upper and lower extremities as well as the trunk. The focus of this review will be on the shoulder as it progresses through these four to six phases to complete a throw. The four phases in football are known as the Early Cocking, Late Cocking, Acceleration, and Follow Through [5]. The biomechanics of throwing a baseball or softball overhead adds the Windup and Arm Deceleration Phases [5]. Although there is typically a starting position in which a football player starts their "windup" to throw and their arm decelerates after they release a football, these are not known as official phases in the throwing biomechanics of throwing a football. For this article, the biomechanics of throwing a baseball will be reviewed related to the shoulder position and motions throughout the six phases [5].

The initial phase is known as the Windup Phase. The Windup Phase begins with the first movement as the athlete transitions from a static balanced position with the athlete's feet and arm set. The Windup Phase is completed when the lead leg reaches maximum knee height, which varies depending on whether the athlete is throwing from a fielding position, pitching from the windup, or utilizing a slide step from the stretch. The shoulder starts in a static, internally rotated position so that the hands are together (paired with a gloved contralateral hand in baseball) holding the ball in front of the chest. The shoulders may be flexed forward to bring the hands and ball overhead during a windup but does not bring the hands and ball overhead during a throw/pitch from the stretch position [5].

The next phase is known as the Stride/Early Cocking Phase and prepares the arm for the throw. The scapula will rotate upward in a retracted position to allow the deltoid and rotator cuff to begin to abduct the arm in the Early Cocking phase. During this phase, the Throwing Shoulder will undergo extreme external rotation (ER) that stretches the anterior musculature in preparation for a forceful contraction. As the body moves forward, the trunk will rotate so that the lead shoulder will be directed toward the target. This phase ends when the lead/stride foot contacts the ground toward the target [5].

During the Late Cocking Phase, the shoulder will reach maximal external rotation (MER) [6]. In order to achieve MER, the scapula remains retracted as the shoulder abducts to 90–110° and externally rotates between 50 and 185° [7, 8]. Additionally, in order to reach MER, there is coordinated eccentric contraction of the subscapularis, latissimus dorsi, and the pectoralis major and concentric contraction of the infraspinatus, teres minor, and deltoid [5]. The shoulder abducts 90–100° as MER is achieved, ending the Late Cocking Phase [5].

The next phase is known as the Arm Acceleration Phase and progresses from MER into a forceful internal rotation (IR) until the ball is released, and the Arm Acceleration Phase is one of the fastest human movements in sports [5, 9]. During the acceleration phase, the rotator cuff muscle activity is three times greater for the amateur pitcher compared to professional pitchers [10]. The release of the ball marks the end of the Arm Acceleration Phase and the transition to the Arm Deceleration Phase.

The Arm Deceleration Phase begins as the ball is released and the thrower attempts to decelerate their arm movement and transition into the Follow Through Phase and to complete the entirety of the throwing motion. Maximal Internal Rotation (MIR) is achieved during the Arm Deceleration Phase. During this phase, the shoulder also horizontally adducts as the arm comes across the body into the Follow Through Phase [5]. Arm deceleration is achieved through the coordinated scapular stabilization by the rhomboids and the serratus anterior in conjunction with the eccentric contraction of the posterior deltoid, infraspinatus, and teres minor [5].

The throwing motion ends with the Follow Through Phase as the shoulder comes to rest and the feet are planted firmly on the ground. The body slows down and comes to rest during the Follow Through Phase and muscle activation is "quiet." [5, 10] The Follow Through Phase is completed when the body is balanced and back under control.

Although the Phases of Throwing remain the same, there are variations in the motion that are based on throwing velocity, pitch types, joint loads, location, and frequency of throwing. These are a few factors that may alter the throwing biomechanics and can add risk of injury to the throwing athlete.

The osteopathic approach to the chief complaint of "my shoulder hurts"

As with any assessment, the Osteopathic approach begins with a proper history beginning with standard information such as age, handedness, trauma, overuse, and past injury medical history. Additional sports-specific history is necessary for the throwing athlete. It is standard to obtain a History of Present Illness/Injury (HPI) for any patient complaint, but there is other specific information that can be asked that may help with the proper diagnosis and management of the presenting injury. It is always important not only to know when and how the injury occurred, but also to know what took place before the injury. These questions would include: time of onset of symptoms; the phase of throwing when they felt or feel the pain; changes in accuracy, velocity, stamina, and strength; changes in training regimens; history of previous injuries to the current joint/location; and other existing or prior injuries that may have altered their biomechanics if they were compensating [11]. Additional questioning may uncover other pertinent information to aid the assessment.

One of the most important questions is whether they are a pitcher or a catcher because the throwing volume, frequency, and intensity are typically higher for these positions. Some of the specific external risk factors for the throwing athlete include the number of pitches thrown in a game, the type of pitches being thrown, and the number of months pitched during a calendar year [12, 13]. However, the number of pitches in a game does not accurately reflect the number of throws an athlete may complete. There is a significant volume of unaccounted workload from the warm-up pitches off the mound and the pregame warm-up, as well as the throws that may be completed if the athlete plays in the field when they are not pitching [14]. To help obtain a more accurate count of the number of throws for a pitcher, Zaremski et al. [15] conducted the first study that counted all pitches off the mound for a pitcher on gameday. The results revealed that the volume of pitches reported during a game is 42 % less than the actual pitches thrown on gameday [14, 15]. Therefore, tracking the pitch count during the game is an incomplete measure of the throwing activity. Therefore, it is imperative to ask another pertinent question about "how many teams do you play on?" This is particularly important for a pitcher who may play in a league during the weekend and tournaments on the weekend as an athlete who may pitch for more than one team but who also may play different positions when they are not pitching.

Table 1: Risk factors for baseball pitchers.

• Pitching while fatigued
• Throwing too many innings over the course of the year
• Not taking enough time off from baseball every year
• Throwing too many pitches
• Not getting enough rest
• Pitching on consecutive days
• Excessive throwing when not pitching
• Playing for multiple teams at the same time
• Pitching with injuries to other body regions
• Not following proper strength and conditioning routines
• Not following safe practices while at showcases
• Throwing curveballs and sliders at a young age
• Radar gun use

Another question that is especially pertinent to those who live and play in warmer weather climates is "when was the last time you had 1–2 weeks off from throwing during a lesson, practice, or game?" Sports like baseball and softball are year-round in these warmer climates, and even if their primary team may have a weekend off, baseball and softball players may be asked by another local or an out-of-state team traveling to the warmer climate for an event. One of the major benefits to youth throwers have been rule changes and recommendations to limit the pitch count. Many leagues have implemented rules to limit the pitch count, such as to keep the total pitches under 80 throws per game, pitching for less than 8 months in a year, as well as limit the use of curve balls and sliders at younger ages [13–20]. Some of the leagues maintain strict rules as to the number of pitches thrown, whereas others only consider total innings [15–17]. Only considering total innings is problematic; it is a less accurate representation of pitching load because some innings may be under 10 pitches while others may take 30 or more pitches thrown to get out of the inning. In addition to the other risk factors mentioned previously, there have been multiple key risk factors, which have been identified and noted in Table 1 by MLB Pitch Smart [15, 18]. Finally, it is important to know if the athlete plays another other sport because this may allow some downtime from throwing to help overuse and also allow the athlete to improve coordination, balance, and overall athleticism through neuromuscular facilitation [19].

Osteopathic physical examination

Osteopathic physicians complete medical training that is uniquely focused to assess the whole person by integrating a holistic approach on maintaining homeostasis. The osteopathic approach to the physical examination of overhead-throwing athletes would begin with a full assessment of the biomechanical chain involved in throwing. The goal of this approach is to detect musculoskeletal imbalances that may lead to current or future injuries. The systematic and holistic osteopathic approach focuses on treating the whole person in not only identifying the injury but also the anatomic and physiologic changes that may have led to the injury. There is the potential for future problems if the provider only focuses on the local area of pain without addressing the problems surrounding the injured body part. The identification of these imbalances at the time of injury can help improve rehabilitation, recovery, and return to play [14, 20–22]. Additionally, the identification of these imbalances during a preparticipation examination (PPE) before an injury occurs can lead to the prevention of future injuries in these athletes [14, 20–22].

When completing an osteopathic musculoskeletal examination, the evaluation starts with TART (Tenderness, Asymmetry, Restriction of Motion, Tissue Texture changes) combined with the evaluation of the entire upper-extremity biomechanical chain. This approach provides a complete assessment and evaluation of the cervical and thoracic paraspinals as well as the shoulder, peri-scapular area, upper arm, elbow, forearm, wrist, and hand [14].

It is important to start with a thorough inspection for any scapular, shoulder, or muscular asymmetry. In many throwing athletes, the dominant throwing shoulder would ride lower than the nonthrowing shoulder [20]. After inspection, the osteopathic physician will assess for changes in muscle tone and tissue texture of the periscapular muscles including the rhomboids, trapezius, and levator scapulae as well as any first-rib restrictions. Additionally, the osteopathic physician will conduct a TART assessment of the muscles around the shoulder including the deltoid, rotator cuff muscles, biceps, triceps, and pectoralis. The assessment is completed with an evaluation of the cervical and thoracic paraspinals and can be expanded to include the lumbar spine, sacrum, and pelvis for any somatic dysfunctions.

The physical examination will still also include standard assessments for range of motion (ROM) of the cervical spine and shoulders. Abnormalities in the ROM of the shoulder can be predictive of injury. It is a common finding in overhead throwers to have a shoulder with an increased ER and reduced glenohumeral internal rotation (GIRD) [20], 21. There is a positive predictive value for shoulder pain due to GIRD if there is a difference of more than 17 degrees of IR compared to ER [21, 22]. Additionally, abnormalities in the TRM, calculated by the addition of ER and IR at 90°, may predict a throwing injury. A shoulder in an overhead thrower is more likely to be injured if there is greater than 5° difference in TRM in the throwing shoulder compared to the nonthrowing shoulder [21, 22]. After the completion of the TART assessment, the common shoulder specialized tests should be performed. These include specialty tests such as the Neer Impingement, Hawkins, Empty Can, O'Brien's, and apprehension tests.

As with any proper musculoskeletal physical examination, strength should be assessed in the upper extremities compared with the strength in the opposite, nonaffected, nonthrowing extremity. It is also imperative to assess the neurovascular integrity of the upper extremity and to include a side-to-side comparison. Distal pulses and sensation in all nerve distributions of the upper extremity should be assessed. Any alterations in sensation, color, temperature, or capillary refill of the digits should be documented. This assessment may uncover weaknesses as well as changes due to rare issues in throwing athletes such as thoracic outlet syndrome and upper-extremity effort thrombosis.

This thorough, comprehensive, and holistic osteopathic approach is paramount for proper diagnosis and treatment. The osteopathic examination will be able to identify any focal deficits, injuries, or imbalances that may increase the risk of future injury as well as contribute to the current injury. Early detection of biomechanical risk factors during a comprehensive osteopathic PPE can significantly reduce the risk of injury during the season. The osteopathic physician can then counsel the overhead athlete regarding any findings of musculoskeletal imbalance or deficits. The osteopathic physician can subsequently incorporate stretching and strengthening exercises that can prevent injury during the training period as well as throughout the season [14].

Common shoulder injuries in overhead throwing

Shoulder impingement: rotator cuff pathology and bursopathies

The pathologies of the rotator cuff are more common in adult collegiate and professional throwing athletes compared to youth and adolescent athletes [2, 3, 19]. They are usually the result of an acute traumatic event, or an external or internal impingement. An acute traumatic event could occur from throwing, fielding, or sliding. External (or secondary) impingement is felt to be due to deficits in muscular and/or proprioceptive control. Internal impingement is most commonly due to tightness of the posterior capsule and the soft tissue structures of the posterior shoulder.

Mechanism of injury

The mechanisms of injury vary between the three main causes of rotator cuff pathology. Acute trauma is a less common cause of rotator cuff pathology in overhead-throwing athletes. Although injury to the rotator cuff can occur while throwing, it is more commonly due to a trauma when trying to field the ball or slide into a base in baseball or softball as well as during a tackle in football.

The primary theory for rotator cuff injury (RCI) is known as external impingement (EI). There are multiple contributing factors that lead to EI including poor muscle control of the rotator cuff muscles and the subtle instability of the glenohumeral joint (GHJ). The decreased muscle control of the rotator cuff leads to a deficiency in the compressive forces that are necessary to provide stabilization of the humeral head and the glenoid during overhead movements. The instability caused by poor muscle control may then lead to repeated contact of the conjoined tendon of the supraspinatus and infraspinatus with the acromion and/or the subscapularis with the coracoacromial arch.

The secondary theory for RCI is known as internal impingement (II). Similar to EI, the development of II is due to several contributing factors. One of the primary causes of II is having excessive tightness of the posterior shoulder capsule and/or the posterior shoulder musculature. The excessive posterior tightness will lead to inappropriate contact of the posterior aspect supraspinatus and the superior portion of the infraspinatus tendon with the posterior glenoid rim. Subsequently, repetitive contact will lead to partial-thickness tearing of the articular side of the tendons as well as fraying of the posterior superior glenoid labrum.

Signs/symptoms

The overhead-throwing athlete will typically present with a chief complaint of shoulder pain that is worse with throwing and other overhead activities. The pain can be acute following a traumatic event or can gradually increase over time with chronic repetitive microtrauma. The pain may be local or radiate down to the lateral deltoid. The athlete may complain of weakness as well as loss of ROM of the shoulder. The pain or weakness may occur when trying to lift or carry a heavier object. As symptoms progress, the overhead thrower may complain about pain when putting pressure on the shoulder when lying on the affected side during sleep [23]. On occasion, the overhead-throwing athlete tries to play through the pain by modifying the volume or intensity of throwing. If the overhead athlete alters their biomechanics to compensate, they could cause additional issues. Therefore, it is incumbent on the medical staff to include in their evaluation an assessment for compensatory changes in the joints and muscle groups.

Osteopathic physical examination

As discussed in detail above, the recommended examination would follow the osteopathic approach. The key findings on the osteopathic physical examination would include tenderness to palpation, a loss of shoulder ROM, decreased strength, and positive impingement signs.

Visual inspection of the shoulder may reveal a sulcus due to muscular atrophy of the supraspinatus or infraspinatus [20, 23]. Tenderness to palpation is typically positive along the involved rotator cuff tendon insertion and on occasion in the proximal muscle.

The shoulder ROM may not be limited for all persons; however, there can be pain elicited during portions or the entire ROM, known as the "painful arc." It is important to visually inspect the scapulothoracic motion during the shoulder ROM assessment because scapular dyskinesis may be present. Scapular dyskinesis can be a contributory factor to developing the pathology or a secondary consequence of the injury [23].

It is important to assess the strength of the shoulder musculature through manual muscle testing. There may be supraspinatus weakness due to a tendon tear when assessing shoulder abduction in the scapular plane [20]. The Jobe or Empty Can Test assesses the strength of the supraspinatus with the arm abducted and the thumb pointed down. Infraspinatus and teres minor weakness can be assessed with resisted ER with the arm adducted to the side. Subscapularis weakness can be assessed with resisted IR either through the "belly press" or the "lift-off." The "belly press" is performed when the arm is internally rotated with the palm/fingers against the belly and applying resistance [23]. The "lift off" test is a manual muscle test that is performed with the shoulder internally rotated with the dorsum of the hand resting on the back, and a positive test reveals weakness if the athlete is unable to "lift off" his hand from their back when resistance is applied. Scapular weakness should also be assessed by an inspection for "winging" when attempted to perform a wall push-up [20]. Finally, there is a number of special tests for rotator cuff pathology of the supraspinatus such as weakness with the Empty Can Test, and pain with the Hawkins and Neer Impingement tests [20].

Imaging

The three primary options for imaging when evaluating rotator cuff pathology are Plain Radiographs (X-rays), Ultrasound (US), and Magnetic Resonance Imaging (MRI). The greatest benefit of an X-ray in this setting is to rule out other pathologies; however, there are some findings that may suggest that there may be rotator cuff pathology. The four primary views that may demonstrate these findings are the Anterior-Posterior (AP), true AP (Grashey), Scapular Y (lateral), and Axillary views. Although the AP view does not typically reveal a finding suggesting of rotator cuff pathology, the Grashey view activates the deltoid, so it may demonstrate superior migration of the proximal humeral head when there is a chronic large tear of the rotator cuff [23]. The lateral Scapular Y view may reveal abnormalities of the acromion, which may have contributed to the pathology, and if there is an anterior or posterior subluxation of the humeral head, there may be joint space narrowing on the Axillary view [20, 23].

US has been an emerging modality for the assessment of the rotator cuff, particularly as the resolution of the technology has been advancing. US has multiple benefits such as lack of radiation, time, cost, and most importantly, it can provide immediate static and dynamic assessments. It has been proven that there is no significant difference in the ability of US to rule in or out partial- and full-thickness tears of the rotator cuff compared to MRI and magnetic resonance (MR) Arthrogram [24].

However, despite these findings, the MRI remains the gold standard for imaging of the shoulder for suspected rotator cuff pathology. The greatest benefits are its ability to determine the presence and size of a tear, location of the tear, and retraction of the tendon. Additionally, it can also assess for muscle atrophy as well as chronic degenerative changes of the muscle, tendon, and bony insertion [20, 23, 25].

Osteopathic approach to treatment

The spectrum of pathologies related to shoulder impingement include bursitis, rotator cuff tendinitis, and partial- and full-thickness tears, and the exact treatment depends heavily on whether a tear is present and the extent of the tear.

However, an approach to treat only the resulting pathology will only lead to additional problems in the future if the cause of the pathology is not addressed. As discussed, the majority of the pathology to the rotator cuff and surrounding soft tissue is related to deficits in the biomechanical chain that lead to repetitive EI or II. This is where the physician with osteopathic training can make the most significant difference in the treatment, management, and prevention of future injury. Specific osteopathic treatments and their outcomes will be included in their own section for the common shoulder pathologies.

There are many traditional and other emerging treatments for rotator cuff and bursa pathologies from shoulder impingement. These include the traditional RICE (Rest, Ice, Compression, Elevation) approach as well as physical therapy, medications such as acetaminophen and non-steroidal anti-inflammatories (NSAIDs), injections (corticosteroids, regenerative orthobiologics), and surgery. The American Academy of Orthopedic Surgeons (AAOS) has created clinical practice guidelines (CPG) for rotator cuff pathology [26]. Overall, rotator cuff pathology can be broken into various categories to help delineate the best treatment options. These categories can be based on whether the patient is symptomatic or asymptomatic and whether there is no tear, a partial-thickness tear (PTT) or a full-thickness tear (FTT).

Asymptomatic tendinitis is rare, but incidental PTT and FTT are found frequently on MRIs of asymptomatic patients, ranging from 8–40 % to 0–46 % respectively [27]. Asymptomatic rotator cuff pathology is typically treated conservatively with nonoperative management, whereas some symptomatic pathology will undergo early surgical management. Physical therapy is a first-line treatment for rotator cuff tendinitis, PTT, FTT for symptomatic and asymptomatic patients based on patient-reported outcomes (PRO) [26, 27]. Physical therapy should include assessment of the shoulder ROM as well as the biomechanics of the athlete while throwing. The treatment should focus on improving the deficits and correcting flaws in the biomechanics [1, 3, 6, 8, 9]. Over-the-counter (OTC) and prescription NSAIDs can help with decreasing inflammation and provide relief of pain for those with symptomatic rotator cuff pathology.

There is also moderate evidence that a single corticosteroid injection has proven to be effective in the short-term reduction of pain and improvement of function with tendinitis, PTT, and FTT [26, 28]. Although multiple corticosteroids can provide pain reduction, there is concern that the corticosteroid may compromise the integrity of the tendon [26], 28. Although it is not specifically addressed in the

AAOS CPGs, the use of US guidance for needle placement is paramount when injecting a corticosteroid because it is well-known that direct injection into the tendon can have serious deleterious effects and weaken the tendon, putting it at risk for complete rupture. A large cohort study of 1,025 patients revealed that corticosteroid injections of the shoulder were associated with a raised risk of cuff tendon tears by 7.44 times compared to the noninjected patients [28].

Platelet Rich Plasma (PRP) is a promising option because of the adverse effects of the corticosteroids, and there is evidence that PRP improves repair rates when utilized to augment surgical repair [29]. There have been a few studies reporting that an injection of PRP can also improve pain and function, but the studies have not been conducted for a long enough time frame to determine the effect of preventing a re-tear [29]. One such study on 20 patients with a 91 % follow-up rate revealed a statistically significant reduction of pain with the Visual Analog Scale (VAS) and function with the Constant Shoulder Score and the UCLA shoulder score at 8 weeks and 3 months respectively [30]. Unfortunately, there are too many variabilities between PRP concentrations among the various systems and there has not been any clear cellular range that has been proven the most efficacious for rotator cuff pathology. Therefore, the AAOS CPGs conclude that there is limited evidence on the efficacy of PRP for PTT and FTT [26].

There are multiple variations on surgical techniques for rotator cuff tears depending on whether the tear is a low- or high-grade PTT or FTT. The AAOS recommendations is that surgical management may be appropriate for FTT and PTT that have failed conservative nonoperative management. There is strong evidence that liquid PRP augmentation to surgery decreases the incidence of re-tears and increases the cross-sectional area of the postoperative tendon compared to surgical management without PRP augmentation [26, 29].

Return to play

The return to play (RTP) of overhead-throwing athletes should occur only after there is resolution of symptoms at rest and with overhead activity. The overhead thrower should have completed therapy that not only addressed the direct pathology of the rotator cuff, but also corrected the deficits found that lead to EI and II with specific focus on the scapular stabilizers and posterior shoulder tightness. The throwing motion should be assessed, and abnormal motions should be corrected. The motion should be integrated into a functional analysis of the throwing biomechanics [1, 3, 6, 8, 9, 14, 20, 31]. The throwing athlete should also follow a Return To Throwing Program/Protocol, and the athlete may slowly increase their velocity and distance to return to sport as tolerated. The Throwing Program/Protocol should be individualized for each throwing athlete.

Pitchers (and parents for adolescents and youth) should be advised regarding the recommendations related to pitch count, types of pitches, and the total time pitching throughout the calendar year [13–20, 31]. Ultimately, it is the responsibility of the athlete (and parents) to make sure that they track the throwing volume and adhere to the recommendations. However, there is always a concern regarding compliance, particularly in sports leagues and tournaments that do not follow throwing guidelines.

Shoulder instability: labral pathology and dislocations

The shoulder is one of the most unstable joints of the body with a shallow cavity surrounded by a labrum. The glenoid labrum is a fibrocartilaginous ring that is attached to the outer rim of the glenoid and plays a vital role in shoulder stability. The anatomy of the GHJ allows for significant multidirectional mobility that is necessary for throwing. Disruption of the labrum alters the balance between mobility and stability. Injuries to the labrum are frequently due to trauma or overuse injuries from repetitive motions such as throwing. The risk factors for labral injury and dislocations are associated with male sex, adolescence, and a history of trauma. There are a number of different labral tears that have been described by the orientation and the location of the tear. Labral tears include the SLAP (Superior Labrum Anterior to Posterior) tear, Bankart lesion (Anteroinferior Glenoid Labrum), and the GLAD (Glenolabral Articular Disruption) lesion. Any of these lesions may have a significant impact on an athlete's ability to throw due to instability; however, surgical management of the tear may also impair throwing because the surgical correction may negatively impact the mobility necessary to throw at the pre-injury level [32–35].

Mechanism of injury

Shoulder Instability is a result of the disruption of the normal GHJ anatomy and the glenoid labrum. An acute traumatic event is the most common cause of a labral tear and shoulder dislocation. The location of tear of the labrum is due to the forces exerted on the labrum based on the insulting trauma. The impact of the trauma will cause the disruption of the labrum, and the shoulder may dislocate at the time of the trauma or be susceptible for a future dislocation due to the tear caused during the trauma. The labral tears are known as SLAP, Bankart, and GLAD, as mentioned previously, whereas the dislocations are named by the direction of their instability: Anterior, Posterior, and Multidirectional. However, not all labral tears are from acute trauma and may occur due to repetitive motions that apply a compressive force across the labrum as occurs with overhead throwing [32–35]. The article will primarily focus on the SLAP lesions due to the greater likelihood of this pathology in the overhead-throwing athlete, compared to Bankart and GLAD, as well as space limitations.

SLAP lesions

SLAP lesions were first described by James Andrews but were named by Snyder based on the location of the lesion [36, 37]. Initially, the SLAP lesion was considered an injury that occurs in young overhead-throwing athletes; however, SLAP lesions were later found in other populations as well as in MRIs of asymptomatic overhead-throwing athletes. The originally described cases of SLAP lesions were secondary to an acute traumatic event such as a fall on an outstretched arm with the shoulder in varying degrees of abduction and is now known as a compression-type injury [36–40]. There are also traction-type injuries from a sudden jerking movement, after lifting a heavy object, or an unexpected pull on the arm. However, there are also SLAP injuries due to attrition over time, which is the most likely mechanism of injury in the overhead-throwing athlete and which has been described as a peel-back mechanism. During the throwing motion, the arm is in an abducted and externally rotated position during the Late Cocking phase, and the combination of the bicipital force and the posterior humeral glide causes the posterosuperior quadrant of the glenoid and posterior labrum to begin to peel off [38]. However, there is debate whether the peeling off is cause by this mechanism or if it occurs during the early deceleration phase of throwing [39]. SLAP lesions are commonly found in asymptomatic overhead throwers such as baseball players [40]. These findings have led to a growing consensus of experienced physicians caring for Major League Baseball (MLB) athletes to feel that these SLAP tears and adaptive changes that occur in high-level, experienced overhead throwers [41].

Bankart lesions

A Bankart lesion develops when the glenoid labrum, most commonly the anterior-inferior labrum, is torn with associated tearing of the associated ligaments. When the anterior-inferior rim is disrupted with the addition of an avulsed bone fragment or a glenoid rim fracture, it is known as a bony Bankart [42]. "Soft" Bankart lesions, without the associated fracture, involving the inferior anterior labrum are more common [43].

GLAD lesions

Glenolabral Articular Disruption (GLAD) lesions are an infrequent (1.5–3%) type of traumatic labral tear [44]. GLAD lesions are a combined glenoid cartilage and labral injury due to trauma. The typical presentation is a complaint of anterior or global shoulder discomfort. GLAD lesions are an important differential diagnosis in managing shoulder pain following trauma. The typical cause of a GLAD lesion is an adolescent male who had fallen on an outstretched arm that is abducted and externally rotated against an adduction force [45], such as diving for a catch.

Dislocations: anterior, posterior, and multi-directional

The shoulder joint is the most commonly dislocated joint in the human body. Shoulder dislocations are more commonly caused by trauma rather than an atraumatic dislocation. The joint can dislocate anteriorly, posteriorly, or inferiorly. Anterior dislocations are by far the most common and comprise approximately 97 % of all shoulder dislocations. Overall, dislocations are not a common throwing injury; however, the athlete may injure and dislocate the shoulder during another activity while playing the sport such as fielding or a collision. A throwing athlete could also dislocate the shoulder while throwing if there was pre-existing damage to the labrum or in the setting of hyper-mobile joints and ligamentous laxity, but this is relatively uncommon.

Anterior dislocations are typically due to a high-energy or high-impact injury. The primary mechanism involves a fall on an outstretched hand while the shoulder is in abduction and ER. Posterior Dislocation is typically due to a fall on an outstretched hand with the shoulder in adduction and IR. A Posterior Dislocation may also occur due to a direct anterior trauma to the shoulder that forces the humeral head out the back of the glenoid cavity.

Unlike unilateral instability of the shoulder, multidirectional glenohumeral instability is typically atraumatic in onset. Athletes will typically have generalized joint laxity in association with rotator cuff weakness in sports requiring overhead arm motions. It is believed that subtle instability of the GHJ and poor muscle control of the rotator cuff muscles cause a deficiency in the compressive forces needed to stabilize the glenohumeral during overhead movements.

Another theory is that excessive tightness of the posterior shoulder capsule and/or overlying musculature leads to the inappropriate contact of the posterior region of the supraspinatus and the superior aspect of the infraspinatus tendon with the posterior glenoid rim, resulting in fraying of the posterior superior glenoid labrum.

Signs/symptoms

The signs and symptoms for labral injuries vary depending on the examination trauma, but all labral injuries typically involve pain in the shoulder. Acute traumas such as a dislocation will have immediate symptoms; however, injuries from repetitive overuse may gradually increase over time but can also occur abruptly.

An athlete with a labral tear and/or dislocation will frequently present with shoulder pain. An athlete with an SLAP lesion typically has less acute pain than a patient with a dislocation. The pain is typically worse when the shoulder is in specific positions or when doing certain activities. These symptoms may present as a dull or aching pain in the shoulder, particularly overhead lifting. Other times, it may present as a painful feeling of clicking, popping, or grinding in the shoulder during movement.

The athlete with an acute dislocation will have significant pain and a visible deformity unless the shoulder was self-reduced. Athletes with labral tears or history of a dislocation may complain of shoulder pain with overhead activity (throwing) and may also note a feeling of instability. A labral tear will not likely present with a deformity unless there is an acute dislocation associated with the labral tear.

A dislocated shoulder will likely have a deformity, unless the joint self-reduced; however, in that case, the deformity would be different. An anterior dislocation will have a deformity of the shoulder with the humeral head visible anteriorly and prominent acromion. The athlete will typically be holding the arm in an internally rotated position to alleviate additional pain from gravity pulling the arm further out of the socket and stressing the soft tissue. The throwing athlete may report that they have a "Dead Arm" due to a transient loss of sensation and/or numbness in the involved extremity. The dislocation may cause injury to the Axillary nerve, which is the most commonly injured structure during traumatic anterior shoulder dislocations and has been reported in 5–35 % of the cases [46]. An anterior dislocation may also cause a Bankart lesion or Hill-Sachs lesion.

A posterior dislocation will typically present with signs and symptoms such as a loss of ER of the shoulder along with prominence of the humeral head on the posterior shoulder. A posterior dislocation may also result in a Bankart lesion.

The throwing athlete with an atraumatic (Multidirectional) dislocation may have specific or nonspecific shoulder pain, depending on the individual. These athletes do frequently have a feeling of subluxation or dislocation of the shoulder with overhead activities, and they do typically have an increased risk of other shoulder injuries.

When an athlete presents with a complaint of shoulder pain with overhead activity including throwing, care should be taken to review the pitch count, types of pitches thrown, and amount of pitching throughout the year [47]. These factors have been shown to increase the risk of shoulder injury.

Osteopathic physical examination

Evaluation of the overhead athlete in a postinjury setting should include a thorough osteopathic physical examination and functional assessment. The evaluation would include task-oriented functional movements to assess the biomechanics of the overhead athlete. The goal of the osteopathic evaluation would be to uncover any of the following deficits across one or multiple regions: mobility, neuromuscular control, muscular endurance, balance, and/or strength.

The key findings on the osteopathic physical examination would include tenderness to palpation, a loss of shoulder ROM, decreased strength, and positive apprehension and instability signs. The overhead-throwing athlete may have generalized ligamentous laxity, such as hyperextension at the elbows, the ability to approximate the thumbs to the forearms, and hyperextension of the metacarpophalangeal joints. It is very common to have positive special tests such as the O'Brien's test as well as the apprehension sign. Also, it is common to have a positive apprehension sign with the anterior dislocation having a positive anterior apprehension test or anterior drawer test, and a posterior dislocation having a positive posterior apprehension test. The presence of a positive sulcus sign is indicative of inferior instability. It is common to have some strength deficits localizing to the scapular stabilizers and rotator cuff muscles. Examination reveals loss of shoulder ROM as well as poor strength.

Imaging

As with most musculoskeletal injury workups, the initial imaging is typically plain radiographs (X-ray). The X-ray should include the Anteroposterior (AP) views with the shoulder in IR and ER, an axillary or modified axillary view, and the scapular Y-view. An MRI can be helpful in evaluating the integrity of the labrum or rotator cuff muscles as well as the evaluation of chronic dislocations.

The imaging for Atraumatic (Multidirectional) Dislocations and Instability is similar to the studies for traumatic instability. Radiographs may assist with assessing for "Little League Shoulder." MRI and US of the shoulder are useful in evaluating for a rotator cuff tear and/or a labral tear. The US provides immediate static and dynamic assessment of the rotator cuff musculature and the labrum. The US also provides the advantage of time and cost; however, the primary disadvantage is that the US cannot assess the full extent of the labrum. For athletes with suspected glenoid labral pathology, MR Arthrogram of the shoulder may also provide additional diagnostic evaluation, but the primary diagnostic purpose of the MR Arthrogram is to assess the integrity of the labrum and the joint capsule.

Osteopathic approach to treatment

The spectrum of pathologies related to shoulder instability include the varieties of labral tears and dislocations, and the exact treatment depends heavily on the pathology. An osteopathic approach to treatment and recovery will not only address the obvious pathology but also work to correct any weaknesses, imbalance, or compensatory changes that have developed following the injury. Injections may help with symptom control (corticosteroids) or healing (regenerative). However, they will not be effective without a proper rehabilitation program and addressing the biomechanical deficits that may have been present. This may be less of an issue after a traumatic dislocation because the athlete could have been structurally sound with proper throwing biomechanics.

Traumatic dislocations are typically unilateral in nature and are often treated surgically due to the high recurrence rates (80–90 %) [46]. On the other hand, atraumatic dislocations are typically multidirectional in nature and can be treated with rehabilitation (initially) or surgically if they are not responding.

There are different treatment options depending on the extent of the tear and the presence and location of a dislocation. An anterior dislocation typically undergoes a closed reduction without or with anesthesia. Techniques include the Kocher method or the Stimson technique [46]. After reduction, the arm should be immobilized for 2–6 weeks in a sling, with gradual ROM and strengthening exercises as tolerated [46]. A posterior dislocation or subluxation of the shoulder can be successfully treated with a rotator cuff rehabilitation program [46]. However, this approach has had variability in the outcomes for the patient to return to sports.

The Atraumatic (Multidirectional) Dislocation frequently is best managed with a customized rehabilitation program including isometric to isotonic exercises for the scapular stabilizers (the serratus anterior, pectoralis and latissimus dorsi muscles) and rotator cuff muscles [46]. These exercises then progress to more integrative and functional activities specific to the athlete's sport.

Surgery may be indicated in those patients whose function is still markedly impaired after a rehabilitation program. Operative treatment that corrects the underlying pathology is therefore being increasingly offered at an earlier stage to patients whose symptoms are refractory to nonoperative measures. However, although surgery may repair the tear and improve stability, it will limit ROM and will make return to throwing even more challenging.

Rehabilitation can be the primary means of nonoperative treatment and management, or it can be a secondary option postoperatively depending on the type of injury. The rehabilitation program will begin with restoring a pain-free ROM of the throwing shoulder, regaining strength in the shoulder and scapular stabilizers, and initiating a graduated return to throwing program.

For pitchers in particular, time should be taken to review the pitch count, types of pitches thrown, and amount of pitching throughout the year. Therapy should focus on strengthening the scapular stabilizers and rotator cuff muscles. The motions should then be integrated into a functional analysis of the pitching biomechanics. After any abnormal motions are corrected, the athlete may slowly increase their velocity and return to playing the sport as tolerated.

Return to play

As always, a customized rehabilitation program should be developed for every patient. However, there are certain components that are universal, although they may vary in frequency and intensity. The RTP rehabilitation program should include isometric to isotonic exercises for the scapular stabilizers (the serratus anterior, and the pectoralis and latissimus dorsi muscles) and rotator cuff muscles. These exercises can then be advanced throughout the spectrum of the program as the overhead athlete progresses. Eventually the exercises can then be progressed to integrative and functional activities specific to the overhead athlete's sport [1, 3, 6, 8, 9, 14, 20]. There are tenets for the rehabilitation program that are universal to all players. Therapeutic exercises should focus on strengthening the scapular stabilizers and the rotator cuff muscles. ROM exercises should be integrated into the functional analysis of the overhead athlete. After any abnormal motions are corrected, the athlete may slowly increase their velocity and return to playing the sport as tolerated [1, 3, 6, 8, 9, 14, 20].

Return to throwing program/protocol

There are differences between throwing and nonthrowing overhead athletes in the RTP protocol that involves a Return to Throwing Protocol. There are also differences between what sport or position the athlete participates in as an overhead thrower. Baseball pitchers are probably the most unique due to the volume and intensity of overhead throwing. A softball pitcher throws underhand for most of their pitches, so even though the volume may even be higher, the stress on the shoulder is thought to be less and is supported by the incidence of shoulder injuries between baseball pitchers and softball pitchers. A football quarterback may throw a high volume of passes, but in many cases, the volume and intensity of throwing a football is less than throwing a baseball. Therefore, all of this information needs to be considered when developing a progressive, graduated Return to Throwing Program/Protocol. Therefore, the focus of this Return to Throwing section will be on the baseball pitcher, who likely needs to managed more delicately than the other throwers. Overall, it is imperative that the Throwing Program/Protocol should be individualized for each throwing athlete.

Pitchers

There are numerous protocols in use for pitchers based on the type of injury, the past injury history, past and current treatment (surgical vs. nonsurgical), their age (youth, adolescent, young adult, adult), and the time of the season. Many of the protocols and programs are modified from an off-season returntothrowing protocol to focus on further rehabilitating the injured shoulder and the ancillary deficits from compensatory changes and deconditioning. The throwing athletes may slowly increase their velocity and distance to return to playing the sport as tolerated.

Pitchers (and parents for adolescents and youth) should be advised regarding the recommendations related to pitch count, types of pitches, and total time pitching throughout the calendar year [13–20, 31]. Ultimately, it is the responsibility of the athlete (and parents) to make sure that they track the throwing volume and adhere to the recommendations. However, there is always a concern regarding compliance, particularly in sports leagues and tournaments that do not follow throwing guidelines.

Osteopathic treatments for common shoulder pathologies in overhead-throwing athletes

There have been multiple studies that have proven that osteopathic manipulation can provide a significant benefit for throwing athletes with shoulder-impingement and rotator-cuff issues.

The Spencer Technique is a type of osteopathic manipulative treatment (OMT), and its efficacy was evaluated with a prospective cohort of college baseball pitchers. A randomized controlled trial (RCT) compared the benefits of the Spencer Technique vs. sham therapy. A pretreatment evaluation was completed on each participant 1 week prior to the treatments and included ROM (flexion, extension, abduction, adduction, IR, and ER) of the dominant throwing arm, 10 maximum-velocity throws, and self-reported performance utilizing the Kerlan-Jobe Orthopaedic Clinic Shoulder and Elbow Score (KJOC-SES). At pretreatment, both the treatment and control groups had decreased IR and increased ER at the initial evaluation. However, after treatment, there was a statistically significant improvement in IR and abduction in the treatment group receiving OMT with the Spencer technique [14, 47].

Posterior shoulder tightness is a known cause of II leading to injury to the rotator cuff and labrum. The efficacy of OMT to address the posterior shoulder tightness was assessed in an RCT utilizing the OMT technique known as the Muscle Energy Technique (MET). A total of 61 asymptomatic collegiate baseball players were included in the study, and the results demonstrated that there was significant improvement of posterior shoulder tightness. The RCT revealed that the MET performed on the GHJ horizontal abductors provided immediate statistically significant improvements in both GHJ horizontal adduction and IR ROM [14, 48].

OMT has also been shown to be effective in treating subacromial impingement in overhead athletes. A combination of OMT techniques was performed for the treatment and rehabilitation of subacromial impingement. At the end of the 6-week treatment period, the results demonstrated that there was a significant reduction of pain and improvement in function [14, 49]. Another RCT was completed assessing the efficacy of thoracic MET, MET plus soft tissue massage (STM), or placebo for shoulder impingement syndrome. The study followed three groups of 25 patients each with shoulder impingement for 1 year. The results of the RCT revealed that with 1-year follow-up, the Thoracic MET-only group demonstrated significantly greater improvement in pain and disability (Disabilities of the Arm, Shoulder, and Hand [DASH], Shoulder Pain and Disability Index [SPADI], VAS 7-day average) than placebo at discharge, 6 months, and 12 months, and the MET + STM group also provided greater improvement than placebo in the disability assessments [50].

Although there were not any studies that were specific to the use of OMT for shoulder labral tears and dislocations, the treatment of the shoulder, peri-scapular, and cervicothoracic areas are important to address. Following the traumatic injury causing the tear and/or dislocation, the shoulder commonly suffers from instability. The instability stresses the surrounding musculature as these accessory muscles work to help stabilize the shoulder. OMT has been commonly utilized for myofascial issues related to shoulder instability and periscapular dyskinesia (scapular dyskinesia [SD]). There is a randomized controlled study in overhead athletes assessing the treatment of myofascial trigger point–induced SD with dry needling (DN) + OMT compared to OMT alone. The study included 40 overhead athletes (15 men, 25 women) and revealed improvement in pain, function, and ROM in both groups, yet there was a more significant improvement in the combined treatment group [51]. Additionally, scapular manipulation has been shown to be effective for the reduction of anterior shoulder dislocations without analgesia. The prospective study evaluated 111 patients (112 dislocations) with a first-time relocation success rate of 87.5 %, and overall, 97.3 % went without any anesthesia [52].

Discussion

The osteopathic approach to a shoulder injury in the overhead athlete incorporates traditional approaches. However, it additionally includes a holistic assessment of the functional aspect of overhead motion during swimming, throwing, and swinging the upper extremity for hitting. The thorough osteopathic assessment will help identify the global issues that need to be addressed for successful recovery and return to sport.

Following the osteopathic assessment, a plan of management based on osteopathic principles will be formulated by the physician to include a graduated, phased treatment and rehabilitation program. The combination of osteopathic manipulation and soft-tissue techniques will be incorporated with traditional modalities as well as a therapeutic stretching and exercise program. The focus will not only be on treatment, but also future injury prevention, and preparation for a return to unrestricted sporting activity. Osteopathic treatment is performed in conjunction with physical therapy and therapeutic exercises for best results. The treatment and rehabilitation program should include exercises for strength, mobility, endurance, and power, and it should also include core control and lower-extremity strength training.

Conclusions

An osteopathic evaluation to the assessment and treatment of shoulder pathology in the throwing athlete is beneficial to their overall health and wellness. The holistic approach to evaluation and treatment helps identify issues in the biomechanical chain throughout the phases of throwing. Osteopathic evaluation and treatment are integral to the success of injury prevention and treatment of the overhead athlete. The incorporation of Osteopathic Physicians with the Sports Medicine providers for every team of collegiate, amateur, and professional overhead sports should become a medical standard of care.

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