Common Injuries in the Adolescent Throwing Athlete

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INTRODUCTION

Shoulder and elbow pain in the adolescent population is quite different from the adult population. The difference relates to the immature bone structure of the shoulder and elbow region.

The physis or epiphyseal plate is where future bone is laid down and is constantly changing during the years of growth. The relative weakness at the physis and decreased resistance to shear and tensile forces compared to the surrounding ligaments, tendons and muscles predisposes this area to potential injury [1-3]. Therefore, it is important to take into account the maturation of the bone including the closing of ossification centers when evaluating the immature athlete.

Important ages to remember for closure of the ossifications centers of the shoulder and elbow region include the upper part of the glenoid (ages 16-18 yrs), the proximal humerus (age 17-18 yrs), the lateral epicondyle (14-16 yrs) and the medial epicondyle (14-16 yrs).

Specific shoulder and elbow injuries in the adolescent athlete will vary from sports to sport. Overhead sports involving baseball and tennis athletes most commonly experience such pain. It is estimated that over 2.5 million youth athletes competed in Little League Baseball in 2009. Lyman et al [4] noted that 26-35 per 100 youth baseball pitchers experienced a shoulder and/or elbow injury during the course of a season. Similarly, thirty percent of pitchers experienced shoulder pain and twenty five percent experienced elbow pain after a specific game [5]. In adolescent elite national tennis players (Boys 16 to 18 years old and Girls 16 years old) over twenty to forty-five percent of all injuries were located in the upper extremity [6]. Of these athletes, 25%-30 % had previous or current shoulder pain, while 22%-25% had previous or current elbow pain.

Potential risk factors for subsequent injury will depend upon the exact sport. In the throwing athlete risk factors having included the number of pitches thrown in a game, the type of pitches and the number of months pitched in a year [6,7]. These findings have lead to recommendation including limiting the pitch count to less than 80 throws per game, limitation in the use of curve balls and sliders, and pitching for less than 8 months in a year to avoid injury [8]. Other studies have started looking at the differences in pitching kinematics and kinetics in adolescent throwers compared to adults to identify biomechanics factors that may contribute to overuse and fatigue [9-11]. Earlier studies of adolescent pitchers suggested an increase in physeal width of the dominant shoulder regardless of symptoms. As the athlete matures, skeletal changes occur

including a significant increase in humeral head and glenoid retroversion as documented by computed tomography. These studies would suggest that youth athletes exhibit similar upper extremity joint kinematics compared to adult athletes. However, recent studies would suggest that youth pitchers show greater variability in these parameters compared to elite adult pitchers. However, it is unclear if the specific parameters or variability is a risk for injury.

COMMON INJURIES-SHOULDER

GLENOHUMERAL INSTABILITY

In the adolescent population, the shoulder is one of the most unstable joints of the body. Lawton's [12] review of shoulder instability in athletes 16 years and younger reported an initial traumatic event in 86% of athletes. Instability was associated with male sex, adolescence, and a history of trauma.

Care must be taken when evaluating the skeletally immature shoulder as a traumatic dislocation is more likely to result in a fracture of the proximal humerus.

In the skeletally mature adolescent athlete, traumatic dislocations are typical unilateral in nature and treated surgically due the high recurrence rates (80-90 percent) [12,13].

Less commonly, adolescent athletes may experience atraumatic dislocations in the setting of hyper-mobile joints and ligamentous laxity. Atraumatic dislocations are typically multidirectional in nature and can be treated with rehabilitation (initially) or surgically [14].

Other athletes, such as baseball pitchers, experience more subtle instability secondary to overuse and weakness of the rotation cuff muscles.

Traumatic: Anterior Dislocations (90 %) vs Posterior Dislocation (5%)

 Mechanism of injury:

- Anterior:
  - High-energy injury, involving a fall on the outstretched hand while the shoulder is in abduction and external rotation

- Posterior:
  - Fall on the outstretched hand with the shoulder in adduction and internal rotation or direct anterior trauma to the shoulder forcing the humeral head out the back of the glenoid cavity.

 Symptoms/Signs:

- Anterior:
  - Deformity of the shoulder with humeral head visible anteriorly and prominent acromion. Athlete will hold the arm in an internally rotated position.
  - Dead arm" due to a transient loss of sensation, and/or numbness in the involved extremity.
  - The axillary nerve is the most commonly injured structure and has been reported in 5 to 35% of traumatic anterior shoulder dislocations.

- May result in Bankart lesion or Hill-Sachs lesion.
- Positive anterior apprehension test or anterior drawer test.

  - Posterior:
    - Loss of external rotation of the shoulder, along with prominence of the humeral head on the posterior shoulder.
    - Positive posterior apprehension test.
    - May result in Bankart lesion

 Imaging:

 Plain radiographs including Anteroposterior (AP) views with the shoulder in internal and external rotation, an axillary or modified axillary view and the scapular Y-view.

 Magnetic resonance imaging (MRI),may be helpful in evaluating the integrity of labrum or rotator cuff muscles, but is more helpful in the evaluation of chronic dislocations.

 Treatment

 Anterior:
- Closed reduction without or with anesthesia. Techniques include Kocher method or Stimson method.
- Following reduction, the arm should be immobilized for two to six weeks in a sling with gradual range of motion and strengthening exercises as tolerated.

Several studies have shown decreased rates of recurrent instability and improved outcomes in patients treated with surgical stabilization of acute, traumatic anterior shoulder dislocation when compared with nonoperative treatment in the adolescent population. Lawton [15] retrospectively reviewed the outcome of surgery verses therapy in 70 cases of shoulder instability in athletes 16 years of age and younger. At more than 2-year follow-up, 70% of the surgical group described their shoulders as better and 90% were performing at pre-injury levels at sports. Both open and arthroscopic surgery appear to result in similar outcomes

 Posterior:
- Posterior subluxation of the shoulder can be successfully treated with a rotator cuff rehabilitation program, resulting in a variable ability of the patient to return to sports [16].
- Surgery is 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 [17].

Atraumatic: Multidirectional Instability

 Mechanism of injury:

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. Sports include gymnastics and swimming, where hyper—mobile joints may help in competition.

 Symptoms/Signs:

The athlete typically will have symptoms of non-specific shoulder pain and a feeling of shoulder subluxation or dislocation with overhead activities. On physical examination, they will have evidence of generalized ligamentous laxity including hyperextension at the elbows, the ability to approximate the thumbs to the forearms, and hyperextension of the metacarpophalangeal joints. In addition to a positive apprehension sign, physical examination will reveal a positive sulcus sign indicative of inferior instability. Athletes typically experience strength deficits localizing to the scapular stabilizers and rotator cuff muscles.

 Imaging:

The radiographic evaluation of atraumatic multidirectional instability is similar to the studies for traumatic instability.

 Treatment:

Customized rehabilitation program including isometric to isotonic exercises for the scapular stabilizers (the serratus anterior, pectoralis and latissimus dorsi muscles) and rotator cuff muscles. These exercises are then progressed to more integrative and functional activities specific to the athlete's sport.

"LITTLE LEAGUE SHOULDER"-PROXIMAL HUMERAL EPOPHYSIOLYSIS

Proximal humeral epiphysiolysis, also known as "Little League Shoulder" is a repetitive strain injury to the proximal humeral epiphysis. It generally occurs in adolescents between the ages of 11 and 15 [18, 19]. Baseball has primarily been the focus of studies looking at this phenomenon

 Mechanism of injury:

Overtraining and/or improper biomechanics seen in overhead sporting lead to repetitive stress and rotational torques that eventually compromise the physis. It is thought to resemble a Salter Harris type 1 fracture with separation of the metaphysis from the epiphysis. Some investigators have postulated that chronic stress injury leads to an alteration in the endochondral ossification center.

 Symptoms/ Signs:

The athlete will have symptoms of pain and discomfort in the superior lateral aspect of the shoulder with dynamic/resisted overhead activities simulating competition level intensities. On examination, palpation along the area of the proximal humeral epiphysis is tender. However, active range of motion (AROM) is usually full and pain free. Pain can be reproduced through resisted strength testing in a functional/overhead position or while inducing torque within the humerus.

 Imaging:

Radiographic visualization of the physis injury is best demonstrated on AP “Comparision” views of the proximal humerus with the arm internally and externally rotated that are compared to the asymptomatic contralateral humerus.

External rotation views show widening of the physis at the lateral aspect, metaphyseal sclerosis, osteopenia or fragmentation.

MRI may confirm the diagnosis if initial radiographs are negative.

 Treatment:

Eliminating painfully activities while allowing the athlete to participate in other positions or cross training until pain free is typical. As radiographic evidence of physis closure can take several months it is typically not used as a marker of when return to offending activities. Once the patient can perform overhead activities in a pain free manner, they are gradually allowed to return to play.

Physical therapy and use of a pitching coach are helpful in correcting any biomechanical deficits that may have contributed to the injury.

Overall, the best treatment would be to prevent injury in the first place.

ROTATOR CUFF INJURIES/LABRAL TEARS

In the young adolescent athlete, injury to the rotator cuff muscles or labrum are less common (2,3,18). They are usually the result of an acute traumatic event, secondary impingement because of poor muscular/proprioceptive control or internal impingement due to tightness of the posterior capsule/shoulder soft tissue structures. Traumatic events typically involve falling onto an outstretched arm or forcibly impacting an immoveable object (ie hitting the boards in hockey).

 Mechanism of Injury:

It is believed that subtle instability of the glenohumeral joint and poor muscle control of the rotator cuff muscles causes a deficiency in the compressive forces needed to stabilize the glenohumeral during overhead movements. This instability may lead to repeated contact of the supraspinatus and/or subscapularis against the acromion or coracoacromial arch respectively (external impingement).

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 superior aspect of the infraspinatus tendon with the posterior glenoid rim resulting in a partial thickness tearing of the undersurface (articular side) of these tendons and/fraying of the posterior superior glenoid labrum (internal impingement)

 Symptoms/ Signs:

Athletes complain of shoulder pain with overhead activity including throwing. Care should be taken to review the pitch count, types of pitches and amount of pitching throughout the year as these have been shown to increase the risk of shoulder injury. Physical exam will reveal loss of shoulder ROM, poor core strength and positive impingment signs.

 Imaging:

Radiographs may assist with assessing for Little League Shoulder.
MRI and Ultrasound (US) of the shoulder are useful in evaluating a rotator cuff tear.
Ultrasound provides immediate static and dynamic assessment of the rotator cuff musculature.
In athletes with suspected glenoid labral pathology, MR Arthrogram of the shoulder may also provide additional diagnostic evaluation.

 Treatment:

Treatment of rotator cuff pathology will depend upon the severity of the tear.

In general, adolescent athletes can be treated conservatively with cessation of the aggravating injury and a focused therapy program.

In pitchers, time should be taken to review the pitch count, types of pitches 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 sport as tolerated.

COMMON INJURIES-ELBOW

“LITTLE LEAGUE ELBOW”

Elbow pain in youth athletes is common, occurring in 18-29% of athletes. Little League Elbow is a term used to describe injuries secondary to a valgus overload to the medial elbow or compression of the lateral elbow that occurs as a result of repetitive throwing motions. The stress leads to tension of the medial structures (ie, medial epicondyle, medial epicondylar apophysis, medial collateral ligament complex) and/or compression of the lateral structures of the elbow (ie, radial head, capitellum).

Osteochodritis dissecans (OCD) typically occurs in ages 13-17 years. Potential risk factors for elbow injury include pitch count, poor biomechanics and fatigue.

 Mechanism of injury:

- <u>Medial:</u>
  - Valgus overload or overstress injury to the medial elbow that occurs as a result of repetitive throwing motions.
  - In the youth athlete, the stress leads to widening of the medial growth plate, traction apophysitis, and pain in the medial elbow.

- <u>Lateral:</u>
  - Valgus overload leads to compressive forces on the lateral aspect of the shoulder. Repetitive stress may lead to Osteochondritis dissecans of the capitellum.

 Symptoms/Signs:

- Medial:
  - Medial elbow pain during the cocking and/or acceleration phases of throwing.
  - Athlete may note a decrease in throwing velocity.
  - Palpation over the medial epicondylar area will reproduce pain.
  - Valgus stress of the elbow may produce medial pain.

- Lateral:
  - Dull achy pain worsened with activity.
  - There may be loss of extension.
  - Athletes sometimes report clicking in the elbow.
  - Lateral elbow pain during the cocking phase of throwing.

 Imaging:

- Plain radiographs may reveal widening/fragmentation of the physis or documentation of an OCD lesion.
- Typical findings with an OCD lesion include flattening of the capitellum, subchondral bone defect and/or loose bodies.
- MRI is helpful in diagnosing physeal, osteochondral, muscular, or ligamentous injuries

 Treatment:

Similar to Little League Shoulder, treatment should focus on rest and the correction of any biomechanical or training deficits. (20) Athletes may consider participating at a different position to limit stress on the elbow. Most medial growth plate injuries will resolve over a 4-6 week period.

Treatment of an OCD will depend upon staging and stability of the lesion.

Non-operative methods of treatment for stage 1 and 2 OCD lesions of the capitellum include activity modification and periods of immobilization (6-8 week break from competitive sports), followed by therapy and range of motion exercises [21]. If symptoms persist over 8-12 weeks and the lesion demarcates on MRI, arthroscopic or open subchondral drilling is indicated [22]. Prognosis worsens with age and physis closure.

Surgical treatment may be indicated if there are persistent symptoms, a loose body, the athlete is approaching skeletal maturity, or if magnetic resonance imaging reveals a fracture through the articular cartilage [23]. Possible surgical procedures are open debridement, subchondral drilling, bone grafting, refixation, chondral transplantation and osteotomy

PREVENTION

Preventative strategies focuses on preseason conditioning, attention to proper throwing technique, gradual increase in the number and intensity of pitches, built-in rest periods, and strict adherence to pitch count guidelines (below) should help in preventing injury.

Age appropriate pitches:
- Fastball (>9yrs)
- Change-Up(>11yrs)
- Curveball (>13yrs)

- Slider, Forkball, Knuckleball (>15yrs)
- Screwball (>17yrs).

Little League Baseball Regulation Guidelines

Pitch Count Limits

Age (yrs)	Per Game	Per Week	Per Season	Per Year
17-18	105	-	-	-
13-16	95	-	-	-
11-12	85	125	1000	3000
9-10	75	100	1000	3000
7-8	50	75	1000	2000

Rest Recommendations

Age: 15-18 years		**Age: 14 years and under**	
Pitches	Days Rest	Pitches	Days Rest
>76	4	>66	4
61-75	3	51-65	4
46-60	2	36-50	4
31-45	1	21-35	4
1-30	0	1-20	4

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