Reducing Cumulative Arm Overuse Injuries in Young Throwers

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ABSTRACT

As year-round participation in youth sports continues to increase, health care practitioners treating child and adolescent athletes will commonly see injuries that are secondary to overuse. Starting with a clinical vignette, this article describes proximal humeral physeal injuries in youth throwers, examines causative factors, reviews common therapeutic modalities, and focuses on preventive measures aimed at reducing such cumulative arm overuse injuries. **[*Pediatr Ann*. 2016;45(1):e15-e20.]**

As participation in organized year-round sports increases, there are a significant number of youth athletes affected by overuse injuries who present to pediatric and adult health care providers seeking treatment. Athletes who throw are especially at risk for overuse syndromes affecting the dominant arm.

ILLUSTRATIVE CASE

A 12-year-old boy who pitches year round for his club baseball team presented with lateral shoulder pain that started about 3 weeks prior. One week before that, his pitching coach taught him how to throw a curveball. Initially, his shoulder pain only lasted about a day after the games in which he pitched, but now the pain had become almost constant. His shoulder pain led to him having trouble pitching.

Upon further questioning, the athlete admits to playing baseball year round since age 7 years. He currently participates on his local Little League team while simultaneously playing on a club travel team. He also recently finished a weekend showcase event where he threw 50 hard pitches in front of many coaches and scouts. The entire family is especially concerned because two of his teammates are currently unable to pitch due to arm pain. They want to know if this is the dreaded "Little League shoulder" and how to prevent future overthrowing injuries. Six weeks after his initial presentation, he was expected to travel to Cooperstown, NY, for a 3-day tournament, and the parents state that the team really needs him to be ready to throw.

His general physical examination was unremarkable. Musculoskeletal examination yielded postural imbalances with forward sloping shoulders, forward head lean, and scapular winging. There was mild swelling of the upper arm and shoulder with tenderness of the posterior lateral proximal humerus. He had a 20-degree internal rotation restriction with increased external rotation when comparing his dominant and nondominant shoulders. Radiographs of the involved extremity and contralateral shoulder are shown in **Figure 1**.

His physical examination and imaging findings were consistent with proximal humeral physis injury, commonly referred to as proximal humeral epiphysiolysis or "Little League shoulder." Immediate cessation of throwing was recommended for at least 12 weeks along with ice, anti-inflammatory medication, and a formal physical therapy program working on improving and equalizing internal and external ranges of motion and progressing to a supervised interval throwing program focusing on mechanics. Upon return to pitching, he should focus on throwing fastball and changeup pitches and refrain from throwing curveballs until skeletally mature.

DEFINITION

Injury to the proximal humeral physis occurring due to recurrent microtrauma associated with overuse is often referred to as proximal humeral epiphysiolysis. It is unfair to refer to proximal humeral epiphysiolysis solely as "Little League shoulder" as the reality is that many youth baseball players participate not only on their local Little League

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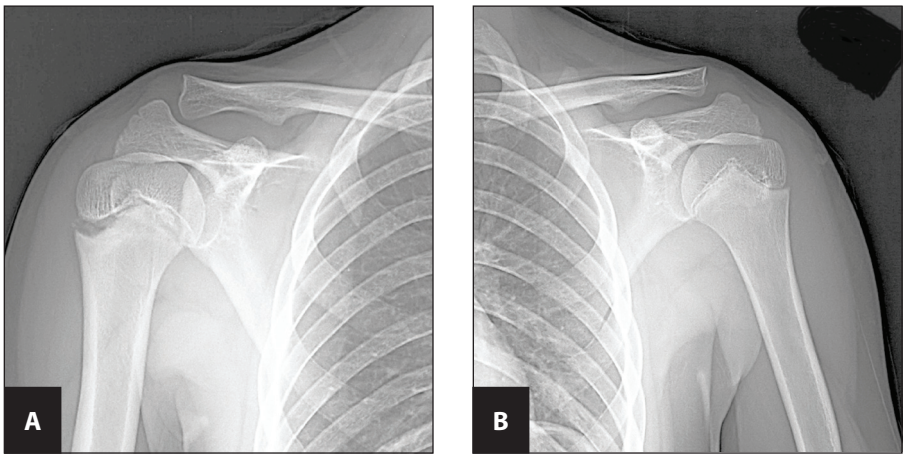

Figure 1. (A) Anteroposterior shoulder radiograph of the affected throwing shoulder. Note the lateral humeral physeal widening. (B) Normal comparison radiograph of the contralateral shoulder.

teams but also play on youth travel ball and club teams unaffiliated with Little League baseball. Also, the condition has been reported in other overhead sports such as volleyball, swimming, and badminton and has even has been described in a skeletally immature gymnast.[1,2] Thus, a more appropriate term would be "youth thrower's shoulder."

SHOULDER GROWTH REGIONS

The human skeleton growth centers are formally referred to either as a physis when this growth center develops under compression (such as the proximal humerus) or as an apophysis when the growth center is under tension (such as the medial elbow epicondyle). The youth thrower faces certain risks influencing osseous development during the first and second decades of life. Skeletal immaturity is a nonmodifiable risk as ligaments and tendons that attach at a growth center are structurally stronger than the growth center themselves. This makes the proximal humeral physis the "weak link" in the kinetic chain of a skeletally immature overhead-throwing athlete.[3]

PRESENTATION

Shoulder pain in children and adolescents can be caused by a variety of conditions such as sternoclavicular joint injury, clavicle fracture, acromioclavicular joint injury, distal clavicle osteolysis, proximal humerus fracture, glenohumeral instability, rotator cuff injury, and youth thrower's shoulder.[4]

Physical examination commonly reveals tenderness to palpation over the proximal humerus with specific tenderness over the lateral aspect. Swelling, weakness, atrophy, and loss of shoulder motion can occur but are less common findings.[5]

IMAGING

Imaging of both the affected and contra-lateral shoulder is required to assess the growth plate and to also rule out other causes of pain such as fracture, benign neoplasms (chondroblastoma, osteochondroma, bone cysts), and uncommon malignancies. Typical radiographic findings of proximal humeral epiphysiolysis include widening of the lateral aspect of the growth center[5] (**Figure 1**). Occasionally sclerosis, fragmentation, and degenerative changes could be present.[5] Magnetic resonance imaging (MRI) is rarely indicated; however, when performed it typically shows increased signal on T2-weighted images[6] (**Figure 2**). Obembe et al.[7] reported that MRI findings in proximal humeral epiphysiolysis demonstrated focal physeal widening in four affected boys with extension of physeal signal intensity into the metaphysis on T1-weighted and gradient echo coronal and sagittal sequences. Abnormal high T2-signal intensity was seen in the metaphysis adjacent to the focal physeal widening in all the boys.[7]

TREATMENT

Overuse due to year-round, single-sport participation is likely the single most modifiable risk factor to arm health of a skeletally immature thrower, with specific and early diagnosis essential when treating injured skeletally immature throwing athletes. Continuous rest periods with avoidance of the repetitive motion of throwing are of paramount importance. A well-outlined program of rehabilitation focusing on proper throwing techniques should be implemented and continued.[8]

Glenohumeral internal rotation deficit (GIRD) is a common adaptive change in overhead athletes due to overexposure to throwing. Adolescent throwers should be examined for GIRD by placing the patient supine with the scapula resting on the examination table. The glenohumeral joint is abducted to 90 degrees, the elbow flexed to 90 degrees, and passive internal and external glenohumeral rotation are measured for both dominant and nondominant shoulders (**Figure 3**).

The criteria for diagnosing GIRD is typically a 25-degree or more loss of internal rotation of the affected throwing shoulder compared with the nonthrowing shoulder. Astolfi et al.[9] in a study of 36 youth throwers demonstrated increased external rotation and decreased internal rotation with increased posterior capsular thickness on ultrasound. Nakamizo et al.[10] evaluated 25 Little League pitchers with 40% having GIRD and increased external rotation in their throwing arm compared with nonthrowing controls and suggested that the development of GIRD happens earlier than previously thought. Meister et al.[11] also evaluated GIRD by examining 294 Lit-

tle League players and determined that the biggest decline in motion occurred between ages 13 and 14 years. In addition, they found that there is a linear decrease in range of motion as compared to age, but did not elucidate the cause.[11]

Specific therapeutic modalities geared to stretching the posterior capsule of the affected shoulder and achieving symmetric glenohumeral joint rotation should be a focus of rehabilitation. Burkhart et al.[12] found that 90% of symptomatic pitchers with GIRD responded to internal rotation stretches over a 4-week period. The primary recommended stretch should be the "sleeper stretch," in which the youth thrower lies on their side with the involved arm placed against the examination table and perpendicular to the body. The elbow is flexed 90 degrees. The patient pushes the forearm toward the table, stretching the posteroinferior capsule (**Figure 4**).

Another aberration is postural imbalance with scapular winging (**Figure 5**), commonly referred to as scapula dyskinesis, which is an imbalance of soft tissue homeostasis of the peri-scapular musculature. It is often observed in youth throwers and can be a cause of secondary shoulder impingement, which in the long term can lead to degenerative changes, specifically of the supra and infraspinatus muscle tendons.[13] Scapula-based rehabilitation programs focusing on improving postural balance and scapular control is another fundamental goal of rehabilitation. The treating clinician is encouraged to refer to therapists adept at treating young throwers.

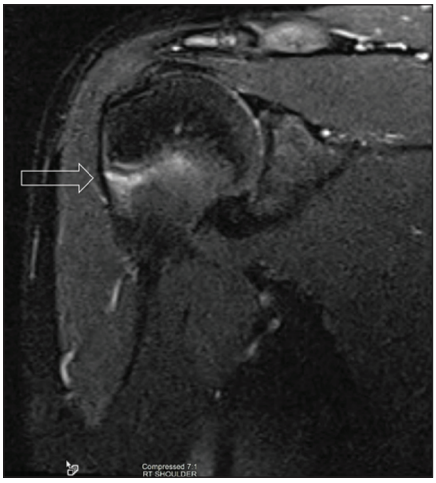

Figure 2. Magnetic resonance image showing increased signal on T2-weighted images (open white arrow).

Once the aforementioned biomechanical concerns have been adequately corrected, the importance of an interval-throwing program prior to returning to competition cannot be ignored.[14] This allows a functional progression back to a sport over a period of several weeks. Acceptable throwing distances and target ranges have been recommended (**Table 1**). The player may only progress to a new phase upon fully completing a prior phase twice. A typical program often consists of eight escalating phases.[14]

How and where the youth athlete throws during rehabilitation is also important to a successful program. Slenker et al.[15] demonstrated that partial-effort pitching significantly lowered loads on the shoulder and elbow in pitchers. They also showed that flat-ground throwing at even the shortest distances had similar biomechanical loads compared with pitching from the mound, yet at significantly lower ball velocity.[15] Pitchers who began using a "crow hop" that used increased lower extremity involvement to facilitate longer distance throws from flat ground had no increase in shoulder or elbow loads. Thus, the mechanical advantages of throwing from a mound or using the crow hop are likely protective during rehabilitation and training throws. These findings may be used to improve rehabilitation programs designed for baseball players returning from shoulder or elbow injury.[15]

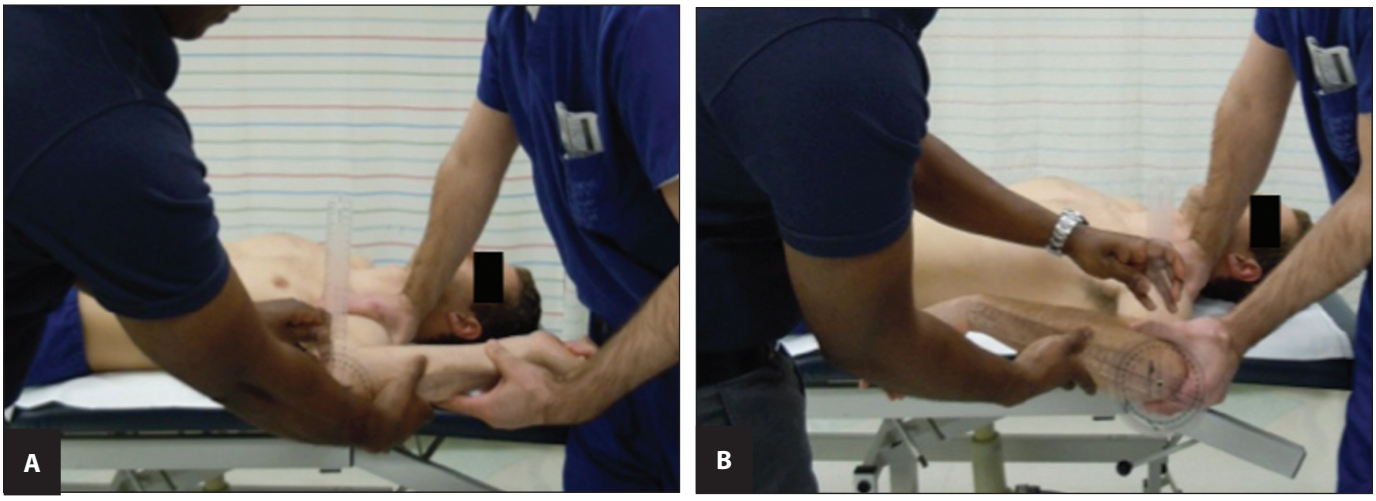

Figure 3. Measurement for glenohumeral internal rotation deficit. The examination is performed with the patient supine with the scapula resting on the examination table while a passive range of motion of the glenohumeral joint is assessed. The glenohumeral joint is abducted to 90 degrees, the elbow flexed to 90 degrees, and (A) external and (B) internal rotation are measured. Maximum rotation is determined by the initiation of scapular motion.

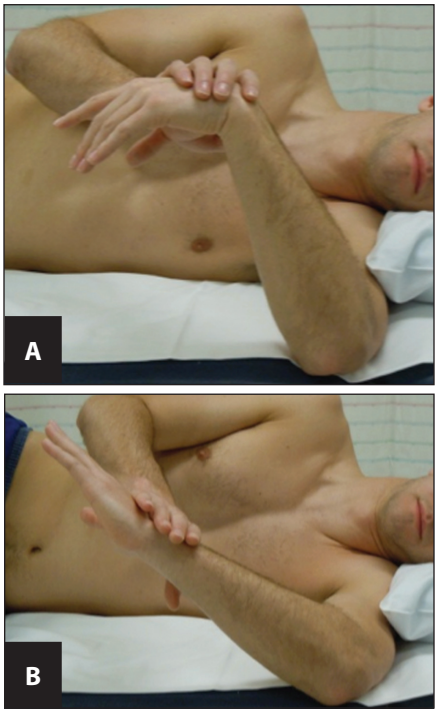

Figure 4. Internal rotation stretches demonstrating (A) the "sleeper stretch" starting position and (B) the engaged stretch.

Figure 5. Scapular winging and malpositon of the right scapula in an adolescent athlete.

TABLE 1.

Acceptable Throwing Distances and Target Ranges

Age (years)	Throwing Distance (feet)
Child (<13)	80-120
Adolescent (13-18)	120
Young adult (>18)	180

Adapted from Axe et al.[14]

RISKS

There are certain common contributing factors that are often reported by young throwers and their families. These include (1) hiring a sought-after pitching coach, who has varying degrees of certification; (2) participation with these pitching coach-based training programs typically requires throwing pitches above and beyond the number asked for by their team, increasing the risk of physeal injury throughout the year; and (3) a well-meaning adult coach and/or parent pushing a child that is experiencing pain to throw past their threshold and inadvertently increase their risk for injury.[16]

Makhni et al.[17] surveyed 203 healthy players with 23% of these players reporting a prior overuse injury. Only 26% of players reported that their arm never hurt when throwing and 20% stated that they hurt the day after throwing. Thirty percent of players reported that arm pain at least sometimes caused them to have less fun playing, and 46% reported at least once being encouraged to keep playing despite having arm pain. Pitchers statistically were more likely to report arm pain while throwing and the day after throwing and to indicate that arm pain held them back from being a better player. Those with prior overuse injury were more likely to have arm pain while throwing, to have arm fatigue during a game or practice, and to be encouraged to keep playing despite having pain.[17]

In a similar study Mellecker et al.[18] surveyed and conducted physical examinations on youth throwers and reported that their screening protocol resulted in positive physical examination findings in 37.6% of 77 players. It is essential that adults help youth pitchers and throwers avoid fatigue, overuse, and improper mechanics. If shoulder and/or elbow pain develop and do not respond within a few weeks to recommended general treatment, a sports medicine physician should immediately evaluate the youth pitcher.

PREVENTION

The question arises: is there any utility in activity modification prior to the onset of arm pain in youth throwers? The answer is undoubtedly yes. Research points to overuse as the principle risk factor.[16-19] The risk of pain in youth pitchers is correlated with the number of pitches thrown in a game and in a season. Adolescents who competitively pitch more than 85 pitches per game, more than 8 months a year, or with arm fatigue are several times more likely to require elbow surgery.[16] Guidelines for inning limits, number of pitches, rest intervals, and throwing programs should be followed for school-age pitchers.[8,20] (**Table 2** and **Table 3**). Multiple appearances in weekend tournaments and moving from pitcher to catcher in the same competition should be avoided.

Poor pitching mechanics also appear to contribute to injury risk.[16] Keeley et al.[21] studied throwing mechanics of youth pitchers and reported initiation of trunk rotation early in the throwing movement can lead to increased forces placed on the glenohumeral and elbow joints. Under-

developed musculature in the rotator cuff may lead to difficulty controlling throwing-arm deceleration.[21] Their findings increase specific knowledge that creates an opportunity to develop pitching mechanics specifically designed for preventing injuries in youth league pitchers.

Educating school-aged pitchers about the importance of throwing at submaximal velocity can help prevent injury. Encouraging youth athletes to avoid showcases where they often throw repetitively with maximal force while scouts and coaches monitor them with a radar gun is another prudent measure to decrease the risk of injury.

Defining the duration of an adequate "rest" period has not reached a definite consensus among parents, coaches, and medical professionals. Communicating the need for an extended period of rest can be challenging for the practitioner and is often disconcerting for the patient and family. In a clinical report on overuse injuries, overtraining, and burnout in child and adolescent athletes, Brenner and the American Academy of Pediatrics Council on Sports Medicine and Fitness[22] recommended that clinicians encourage athletes to take at least 2 to 3 months away from a specific sport during the year and participate on only one team during a season.

Specific to youth throwers, other authors[23] have recommended elimination of throwing for a minimum of 6 weeks after diagnosis of an overuse injury and no throwing for an additional 6 weeks during the strengthening phase of rehabilitation, for a total of at least 3 months of rest from throwing.

TABLE 2.

Little League Baseball Regular Season Pitching Rules

Age (years)	Maximum Pitches Per Game or Day
17-18	105
15-16	95
13-14	95
11-12	85
9-10	75
7-8	50

Adapted from Little League Baseball.[20]

TABLE 3.

Little League Baseball Regular Season Rest Requirements

Age (years)	Rest Requirements (days)
15-18	76 or more pitches: 4 61-75 pitches: 3 46-60 pitches: 2 31-45 pitches: 1 1-20 pitches: 0
7-14	66 or more pitches: 4 51-65 pitches: 3 36-50 pitches: 2 21-35 pitches: 1 1-20 pitches: 0

Adapted from Little League Baseball.[20]

CONCLUSION

Early recognition and treatment is of paramount importance when evaluating a youth thrower with shoulder and arm pain. One of the most common reasons for youth throwers to fail to return to a sport is inadequate rest after injury. A rest period of a minimum 12 weeks is often necessary to allow for complete healing and time to focus on improving mechanics and developmental aberrations. Avoiding showcases, throwing while being measured by radar guns, and multiple appearances during weekend tournaments should also play a role in prevention. Overuse injuries are preventable when underlying contributors (GIRD, scapula dyskinesis) are addressed and enforced pitch counts are consistent with recommended limits. The single most important and modifiable risk factor in preventing injury in young throwers is activity modification and adequate rest periods prior to the onset of arm pain.

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