Preseason Assessment of Radiographic Abnormalities in Elbows of Little League Baseball Players

Andrew T. Pennock, MD, Andrew Pytiak, MD, Phillip Stearns, CPNP, MSN, Joanna H. Roocroft, MA, Jerry Dwek, MD, Peter Kruk, MD, and Tracey P. Bastrom, MA

Investigation performed at the Rady Children's Hospital-San Diego and San Diego Imaging, San Diego, California

Background: Youth baseball has been associated with elbow pain and elbow abnormalities, leading to the implementation of throwing and pitching guidelines. The purpose of the current study was to examine elbow abnormalities on magnetic resonance imaging (MRI) in asymptomatic Little League baseball players and to correlate these findings with the players’ throwing history and physical examinations.

Methods: A prospective study of Little League players who were 10 to 13 years of age was performed. Players were recruited prior to the start of the season and underwent bilateral elbow MRI. All players underwent a physical examination and responded to a questionnaire addressing their playing history and any arm pain. The MRIs were read by 2 radiologists. Responses on the questionnaire and physical examination findings were compared between subjects with and without positive MRI findings utilizing chi-square and analysis of variance techniques.

Results: Twenty-six players were enrolled. The majority (77%) were right-handed and 14 (54%) were a pitcher and/or catcher. Nine players (35%) had 12 positive MRI findings: 7 findings of edema or signal change of the medial epicondyle apophysis, 2 findings of fragmentation of the medial epicondyle, and 3 findings of edema or signal change of the sublime tubercle. The prevalence of positive MRI findings and a history of arm pain were not greater in pitchers and catchers compared with other players. Players with a positive MRI finding demonstrated greater reduction in shoulder internal rotation (12°) compared with the nondominant arm (3°) (p = 0.04). The two factors associated with a positive MRI finding were year-round play (47% of year-round players compared with 11% of non-year-round players; p < 0.01) and working with a private coach (71% compared with 21%; p = 0.02). Additionally, a history of pain was associated with year-round play and a private coach (p < 0.05).

Conclusions: MRI abnormalities involving the medial aspect of the elbow are common in year-round Little League baseball players, especially those with internal rotation deficits and private coaches. Although Little League guidelines potentially lessen abnormalities seen in pitchers, further refinement of these guidelines addressing year-round play, pain, and private coaching should be considered.

Level of Evidence: Prognostic Level III. See Instructions for Authors for a complete description of levels of evidence.

Peer review: This article was reviewed by the Editor-in-Chief and one Deputy Editor, and it underwent blinded review by two or more outside experts. The Deputy Editor reviewed each revision of the article, and it underwent a final review by the Editor-in-Chief prior to publication. Final corrections and clarifications occurred during one or more exchanges between the author(s) and copyeditors.

Baseball is America’s pastime and garners huge popularity around the world. Initial interest and participation typically begin early in childhood, between the ages of 5 and 7 years, with more than 2.5 million American children playing Little League baseball each year10. Although organized baseball provides many benefits for children, a major drawback is sports-related injuries that are typically related to excessive throwing and pitching. Approximately 20% of baseball players between the ages of 8 and 12 years will experience arm pain during a single youth baseball season1–9. This is particularly concerning given the fact that this injury rate has increased over the last 2 decades4. The exact reason for

Disclosure: This study was funded internally by our institution’s orthopaedic research and education fund, the Orthopedic Research and Education Fund of Rady Children’s Specialists, a medical practice foundation; there was no source of external funding for this study. The Disclosure of Potential Conflicts of Interest forms are provided with the online version of the article.
this is unknown but may be attributable to several factors, including increasing year-round baseball participation, earlier single-sports specialization, and greater athlete, coach, or parent pressure. The elbow and shoulder are the most common joints injured in Little League athletes. Common diagnoses involving the elbow include medial epicondyle apophysitis (Little League elbow), flexor or pronator tendinitis, valgus stress overload syndrome, osteochondritis dissecans of the capitellum, tears of the ulnar collateral ligament, and stress fractures. Many of these diagnoses have long-term implications, sometimes necessitating a surgical procedure and putting young athletes at risk for future elbow arthritis.

Although heightened awareness of these injuries has resulted in the institution of Little League pitching guidelines, few scientific studies have critically assessed injury patterns in Little League athletes. The purpose of the current study was to examine elbow abnormalities on magnetic resonance imaging (MRI) in asymptomatic Little League baseball players and to correlate these findings with the players’ throwing history and physical examinations. We hypothesized that pitchers and catchers as well as year-round baseball players would have a greater prevalence of abnormalities about the elbow.

**Materials and Methods**

After internal review board approval was obtained, 26 Little League baseball players were prospectively recruited and provided consent for this study. The study was limited to the 26 players because of the cost of MRI. Players were recruited from a single Little League district in Southern California after the team rosters were created but prior to the start of any games. Players were recruited from the “major division” or the highest league within the district. Four teams existed within the major division and each team had 10 to 12 players. Patients ranged in age from 10 to 13 years and were excluded if they had a contraindication to the MRI or if they were unable to tolerate the MRI. Patients with arm pain at the time of examination or physical examination abnormalities were excluded and were referred to the orthopaedic clinic for further evaluation. In all, 2 patients were excluded. One patient became claustrophobic while in the MRI scanner and could not complete the study. The other patient had ongoing medial-sided pain consistent with medial epicondyle apophysitis.

In the clinic, radiographs confirmed the diagnosis, and the athlete was prohibited from throwing for the season.

A detailed history was taken on each player. The throwing history (see Appendix) focused on several key factors, including years of play, primary position(s) played, months of play per year, number of teams in which each player participated, private coaching history, and age at which various pitches (change-ups, sliders, and curveballs) were initiated. Each player was queried as to having a history of arm pain or history of a throwing injury. Additionally, patients were asked whether or not they were familiar with the Little League throwing guidelines and whether they had ever exceeded these guidelines.

A detailed physical examination of both upper extremities was performed, including range of motion, strength, and stability testing (see Appendix) by one of two board-certified orthopaedic surgeons. Prior to the examination, the surgeons standardized their testing approach. All angular measurements were performed with an electronic inclinometer. Manual strength testing was performed bilaterally and was graded on a scale of 1 to 5. Shoulder instability was defined as a positive physical examination finding for one of the following: apprehension test, Jobe relocation test, and/or posterior load and shift testing. Elbow instability was defined as a side-to-side difference with valgus or varus stress. Each patient then underwent bilateral elbow MRI using an HDxT 1.5-T MRI (GE) machine with the following sequences: axial T1 (echo time of 12 to 13 ms and repetition time of 580 to 610 ms), axial inversion recovery (echo time of 45 to 50 ms and repetition time of 3,475 to 3,500 ms), sagittal T2 multiple echo recombined gradient echo (MERGE) (echo time of 13.5 to 14 ms and repetition time of 600 to

### TABLE I Player Responses to Baseball History Questionnaire

<table>
<thead>
<tr>
<th>Question</th>
<th>Player Response* (N = 26)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No</td>
</tr>
<tr>
<td>Primary position</td>
<td></td>
</tr>
<tr>
<td>Pitching</td>
<td>15 (58%)</td>
</tr>
<tr>
<td>Catching</td>
<td>23 (88%)</td>
</tr>
<tr>
<td>Infield or outfield</td>
<td>14 (54%)</td>
</tr>
<tr>
<td>Play year-round? (≥8 months)</td>
<td>9 (35%)</td>
</tr>
<tr>
<td>Play on multiple teams?</td>
<td>6 (23%)</td>
</tr>
<tr>
<td>Private coaching?</td>
<td>19 (73%)</td>
</tr>
<tr>
<td>Report baseball-related elbow or shoulder pain or injury?</td>
<td>19 (73%)</td>
</tr>
<tr>
<td>Know the Little League throwing guidelines?</td>
<td>9 (35%)</td>
</tr>
<tr>
<td>Exceed prescribed throwing limits?</td>
<td>11 (56%)</td>
</tr>
<tr>
<td>Pitchers only (n = 11)</td>
<td></td>
</tr>
<tr>
<td>Throw curveballs in the last 12 months?‡</td>
<td>5 (45%)</td>
</tr>
<tr>
<td>Throw sliders in the last 12 months?§</td>
<td>7 (64%)</td>
</tr>
</tbody>
</table>

*The values are given as the number of patients, with the percentage in parentheses. †The denominator for this question is the 17 patients who indicated awareness of the Little League throwing guidelines. ‡The mean age when the players started throwing curveballs was 10.4 years (range, 9 to 12 years). §The mean age when the players started throwing sliders was 10.8 years (range, 9 to 12 years).
Results

The mean age of the cohort was 11.4 years (range, 10 to 13 years), and all baseball players were boys. The majority of players were right-hand dominant (20 [77%] of 26 patients). The study cohort had been playing for a mean time of 6.2 years and 65% were year-round baseball players (indicating that they played ≥8 months per year). A variety of positions were represented, with 42% of players being pitchers, 12% being catchers, and 46% being fielders. Twenty-seven percent of the players had attended private baseball camps or had utilized a private pitching or throwing coach. Of the players’ fathers, 12% were the athlete’s head coach and another 27% were the assistant coach. Two-thirds of the patients were aware of the Little League guidelines, but 23% had claimed to have exceeded these limits. The throwing history data are summarized in Table I.

The baseline physical examination findings are recorded in Table II. Shoulder motion was asymmetric between the dominant and nondominant arms, revealing increased external rotation of 4° and decreased internal rotation of 6°. A 10° to 20° deficit in internal rotation in the dominant arm was present in 23% of players and 12% had a >20° deficit. Otherwise, no
significant differences were identified between the dominant and nondominant arms with respect to elbow or shoulder stability, elbow range of motion, carrying angle, or tenderness to palpation.

In all, 27% of the players responded “yes” to having sustained an arm injury from throwing or had experienced arm pain from throwing. Three of these players had sought out medical attention and had received several diagnoses, including an elbow sprain, medial epicondylitis, and an unknown injury that required a cast. A history of arm pain was found to be associated with year-round play (p < 0.01), private coaching (71% compared with 21%; p = 0.02), and loss of shoulder internal rotation (12° compared with 3°; p = 0.04). Year-round play and private coaching were not mutually exclusive variables, as all players with a private coach also engaged in year-round play. If neither year-round play nor private coaching was present, there was an 11% prevalence of abnormal MRI findings, which increased incrementally with the addition of year-round play (to a prevalence of 30%) and year-round play and private coaching (to 71%). There was no significant difference (p = 0.66) in the proportion of players with positive MRI findings who also reported baseball-related elbow or shoulder pain or injury (3 [33%] of 9 players) and those with negative MRI findings who reported

Abnormal MRI findings were not found to correlate with player position, years of play, compliance with Little League throwing guidelines, or a history of arm pain. On univariate analysis, prevalence of abnormal MRI findings was found to be significantly associated with year-round play (47% of year-round players compared with 11% of non-year-round players; p < 0.01), private coaching (71% compared with 21%; p = 0.02), and loss of shoulder internal rotation (12° compared with 3°; p = 0.04). Year-round play and private coaching were not mutually exclusive variables, as all players with a private coach also engaged in year-round play. If neither year-round play nor private coaching was present, there was an 11% prevalence of abnormal MRI findings, which increased incrementally with the addition of year-round play (to a prevalence of 30%) and year-round play and private coaching (to 71%). There was no significant difference (p = 0.66) in the proportion of players with positive MRI findings who also reported baseball-related elbow or shoulder pain or injury (3 [33%] of 9 players) and those with negative MRI findings who reported

Asymmetric MRI abnormalities were observed in the dominant elbows of 9 players representing 35% of the cohort, and 3 of these 9 players had 2 abnormalities. The most common abnormality was edema of the medial epicondyle physis, which was seen in 7 elbows (Fig. 1). Another 3 elbows had edema at the ulnar collateral ligament attachment on the sublime tubercle (Fig. 2), and 2 elbows had fragmentation of the medial epicondyle (Fig. 3). The ulnar collateral ligament was intact with no evidence of tearing in any case. Additionally, the mean ulnar collateral ligament thickness was 1.3 mm in the dominant arm compared with 1.1 mm in the nondominant arm (p = 0.04). No signal abnormalities were seen in the other physes, no osteochondritis dissecans lesions were identified, and there was no soft-tissue abnormality involving the flexor or pronator mass or the triceps.

Abnormal MRI findings were not found to correlate with player position, years of play, compliance with Little League throwing guidelines, or a history of arm pain. On univariate analysis, prevalence of abnormal MRI findings was found to be significantly associated with year-round play (47% of year-round players compared with 11% of non-year-round players; p < 0.01), private coaching (71% compared with 21%; p = 0.02), and loss of shoulder internal rotation (12° compared with 3°; p = 0.04). Year-round play and private coaching were not mutually exclusive variables, as all players with a private coach also engaged in year-round play. If neither year-round play nor private coaching was present, there was an 11% prevalence of abnormal MRI findings, which increased incrementally with the addition of year-round play (to a prevalence of 30%) and year-round play and private coaching (to 71%). There was no significant difference (p = 0.66) in the proportion of players with positive MRI findings who also reported baseball-related elbow or shoulder pain or injury (3 [33%] of 9 players) and those with negative MRI findings who reported

Asymmetric MRI abnormalities were observed in the dominant elbows of 9 players representing 35% of the cohort, and 3 of these 9 players had 2 abnormalities. The most common abnormality was edema of the medial epicondyle physis, which was seen in 7 elbows (Fig. 1). Another 3 elbows had edema at the ulnar collateral ligament attachment on the sublime tubercle (Fig. 2), and 2 elbows had fragmentation of the medial epicondyle (Fig. 3). The ulnar collateral ligament was intact with no evidence of tearing in any case. Additionally, the mean ulnar collateral ligament thickness was 1.3 mm in the dominant arm compared with 1.1 mm in the nondominant arm (p = 0.04). No signal abnormalities were seen in the other physes, no osteochondritis dissecans lesions were identified, and there was no soft-tissue abnormality involving the flexor or pronator mass or the triceps.

Abnormal MRI findings were not found to correlate with player position, years of play, compliance with Little League throwing guidelines, or a history of arm pain. On univariate analysis, prevalence of abnormal MRI findings was found to be significantly associated with year-round play (47% of year-round players compared with 11% of non-year-round players; p < 0.01), private coaching (71% compared with 21%; p = 0.02), and loss of shoulder internal rotation (12° compared with 3°; p = 0.04). Year-round play and private coaching were not mutually exclusive variables, as all players with a private coach also engaged in year-round play. If neither year-round play nor private coaching was present, there was an 11% prevalence of abnormal MRI findings, which increased incrementally with the addition of year-round play (to a prevalence of 30%) and year-round play and private coaching (to 71%). There was no significant difference (p = 0.66) in the proportion of players with positive MRI findings who also reported baseball-related elbow or shoulder pain or injury (3 [33%] of 9 players) and those with negative MRI findings who reported
baseball-related elbow or shoulder pain or injury (4 [24%] of 17 players).

Discussion

A large percentage (35%) of Little League players who are 10 to 13 years of age have baseline MRI abnormalities of the elbow, primarily involving the medial epicondyle as well as the distal attachment of the ulnar collateral ligament. These abnormalities are correlated with year-round play, private coaching, and a loss of shoulder internal rotation. Additionally, a large percentage of these players have a history of arm pain despite the fact that all of these children began their baseball careers after the implementation of the Little League throwing guidelines and nearly all of them were aware of these guidelines. Arm pain also appears to be most closely associated with year-round play and the utilization of a private pitching coach.

There has been a dramatic increase in the number of throwing injuries in youth in the United States. As a result, several injury prevention campaigns have been developed to increase awareness of these injuries, such as Sports Trauma and Overuse Prevention (STOP) through the American Orthopaedic Society for Sports Medicine (AOSSM). Additionally, the major overseers of youth baseball, including Little League Baseball and USA Baseball, have developed throwing guidelines in an attempt to lessen overuse throwing injuries. Pitch count restrictions and mandatory rest days are now required of Little League pitchers. These organizations have also made recommendations about position play, avoiding year-round play (4 months off per year), and postponing off-speed pitches (sliders and curveballs) until later in the athlete’s development, but these recommendations are not enforced. Although these guidelines have potentially lessened the disease burden seen in pitchers, our data suggest that they still may not be enough. In the current study, elbow abnormalities were not isolated to pitchers and were nearly as common in field players. Other recent studies have shown similar trends. In particular, a study of Taiwanese Little League players found that 63% of pitchers had radiographic evidence of separation of the medial epicondyle physis, but 50% of field players also had abnormalities. The exact reason that the current study and the Taiwanese study, which was also performed on high-level, primarily year-round baseball players, failed to show a significant difference between pitchers and field players is unclear. One possibility is that the studies were underpowered. A post hoc power analysis showed that we would have needed 7,882 subjects to have an 80% chance to detect a difference, which would have been cost-prohibitive given our study design. Another possibility is that the current throwing guidelines, implemented before these young athletes began their Little League careers, may be preventing some of the previously observed injuries in pitchers. Finally, many Little Leagues emphasize repetitive long tossing among their field players. This type of throwing regimen, among others, within this skeletally immature population may actually be harming the arm instead of helping it.

Year-round play was found to be associated with pain and was predictive of MRI abnormalities in this study. Some authors have even shown that elbow pain is most closely associated with the cumulative number of hard throws over the course of a season more than with the actual number of pitches in a game. Our data would also suggest that, more than position, it is the number of months of play that drives pain and MRI abnormalities. Therefore, maybe the current guidelines are adequate for in-season play, but strong consideration should be given to creating rules against year-round play. The American Sports Medicine Institute (ASMI) is now recommending 4 months off of competitive baseball pitching and a minimum of 2 to 3 months per year with no overhead throwing of any kind. Furthermore, recent data have shown that the odds of an overuse injury are greater in subspecialized athletes participating in a single sport year-round.

Although the results of this study reveal that physeal change is occurring at the medial epicondyle of the elbow, it also suggests that alterations are occurring through the proximal humeral physis. Our cohort revealed a relatively symmetric change in rotation of the dominant arm relative to the non-dominant arm, with external rotation increasing by 4° and internal rotation decreasing by 6°. This osseous adaptation has been well documented in young baseball players as well as professional baseball pitchers and is thought to occur secondary to morphologic adaptations resulting from throwing prior to skeletal maturity. Shear stress arising from high torque during the arm-cocking phase of throwing produces...
deformation of the relatively weak proximal humeral epiphyseal cartilage, causing humeral retroversion.11. Some have hypothesized that this may be protective against shoulder injury, but this has yet to be confirmed.11,12. Glenohumeral internal rotation deficit, secondary to contracture of the posterior capsule, is not thought to be compensatory but is likely pathologic and has been associated with shoulder and elbow abnormalities in throwing athletes7,13,14. In our cohort, one-quarter of all players had an internal rotation deficit of at least 10° and these patients were more likely to have a history of pain and the presence of MRI abnormalities. Nakamizo et al. also showed a high rate of glenohumeral internal rotation deficit in their study of Japanese Little League pitchers.15. They also found that a glenohumeral internal rotation deficit may occur prior to the development of increased external rotation. These findings suggest that there may be a role for early intervention with a focus on posterior capsular stretching to potentially lessen the likelihood of future pain.

Much attention has been given to throwing mechanics as a potential cause of shoulder and elbow injuries. This belief has led to the increased utilization of private pitching coaches even in preteen baseball players as reflected by our study, in which 27% of players used a private coach. Although biomechanical studies suggest that improved pitching mechanics may generate less humeral internal rotation torque, no study has shown pitching mechanics to be associated with elbow pain, injury, or radiographic abnormality in youth baseball pitchers.16,17. In fact, on the basis of our data, using a pitching coach at a young player age likely leads to the player performing excessive throwing, which may contribute to the athlete’s pain and radiographic abnormalities. Ultimately, a balance must be found between teaching proper throwing mechanics and excessive throwing. For now, maybe the best advice for coaches is to be aware of this problem, to rest throwers any time that they have pain, to incorporate posterior capsular stretching in their training sessions, and to focus on other baseball fundamentals such as fielding and batting during these preteen years when the growth plate is particularly sensitive to damage.

There were several limitations to this study. First, patient recruitment was performed at a single competitive Little League program in Southern California, where year-round baseball is common. Therefore, it is unclear how these data extrapolate to other leagues. Second, radiographic assessment of the elbows was not performed because of radiation exposure concerns. It is unclear if radiographs would have been more sensitive at picking up subtle osseous changes about the physis or fragmentation of the epicondyle. However, a study by Wei et al., looking at radiographic and MRI abnormalities of throwers with symptomatic Little League elbow, showed that MRI was more sensitive in detecting elbow abnormalities22. Finally, patient histories, especially as they pertain to pain and player position, were obtained retrospectively, so they were subject to recall bias.

In conclusion, MRI abnormalities involving the medial aspect of the elbow are common in year-round Little League baseball players, especially those who had glenohumeral internal rotation deficit and used private coaches. Although Little League guidelines potentially lessen abnormalities seen in pitchers, further refinement of these guidelines addressing year-round play, pain, and private coaching should be incorporated to hopefully lessen the high prevalence of arm pain and radiographic abnormalities in this throwing population.