Shoulder MRI Abnormalities in Asymptomatic Little League Baseball Players

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Background: Youth baseball is extremely popular in the United States, but it has been associated with shoulder pain and injury. The incidence of shoulder abnormalities in this athletic population has yet to be defined.

Purpose: To examine abnormalities noted on magnetic resonance imaging (MRI) in the shoulders of asymptomatic Little League baseball players and to correlate these findings with the players' throwing history and physical examinations.

Study Design: Case-control study; Level of evidence, 3.

Methods: A total of 23 Little League baseball players aged 10 to 12 years were recruited. All players underwent a comprehensive physical examination and responded to a questionnaire addressing their playing history and any arm or shoulder pain. Bilateral shoulder MRIs were performed and read in a blinded manner by 2 radiologists. Responses on the questionnaire and physical examination findings were compared between participants with and without positive MRI findings through use of chi-square test and analysis of variance.

Results: The dominant arm was 8.5 times more likely to have an abnormality on MRI compared with the nondominant arm. In all, 12 players (52%) had 17 positive MRI findings in their throwing shoulder that were not present in their nondominant shoulder. These findings included edema or widening of the proximal humeral physis (n = 5), labral tear (n = 4), partial rotator thickness tear (n = 4), acromioclavicular joint abnormality (n = 2), subacromial bursitis (n = 1), and cystic change of the greater tuberosity (n = 1). Two primary risk factors were associated with an abnormal MRI: year-round play and single-sport athletes focusing solely on baseball (P < .05). Players with no risk factors, 1 risk factor, and both risk factors had a 25%, 71%, and 100% chance, respectively, of having an abnormal MRI. A majority of players (61%) had previously experienced shoulder pain, especially pitchers throwing curveballs and sliders (P < .05), but this was not associated with an abnormal MRI.

Conclusion: Abnormalities seen on MRI involving the shoulder are common in Little League baseball players, especially those who are single-sport athletes playing year-round.

Keywords: youth baseball; Little League shoulder; rotator cuff tears; magnetic resonance imaging
While 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 magnetic resonance imaging (MRI) abnormalities in the shoulders of asymptomatic Little League baseball players and to correlate these findings with the players’ throwing history and physical examinations. We hypothesized that pitchers as well as year-round baseball players would have a greater incidence of abnormalities of the shoulder.

METHODS

After internal review board approval was obtained, 23 Little League baseball players were enrolled in and gave consent for this study. 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 highest league within the district. Four teams existed within the major division, each with 10 to 12 players. Prior to recruitment, the research team was present at the Little League registration as well as at tryouts to interact with families, familiarize them with the study, and answer any questions. Recruitment was voluntary and was conducted on a first-come, first-served basis, given that our budget allowed us to study only 23 or 24 players. Patients were considered asymptomatic if they were currently pain free, had never seen a clinician for any shoulder problem, and had never received treatment for a shoulder problem. Patients ranged in age from 10 to 12 years; exclusion criteria entailed any contraindication to an MRI or inability to tolerate the MRI. No participants were excluded from the study, and all were able to complete the MRI.

A detailed history was taken on each player. The throwing history focused on several key factors, including years of play, primary positions played, months of play per year, number of teams on which each player had participated, private coaching history, and age at which various pitches (change-ups, sliders, and curve-balls) were initiated. Participants were asked whether they had a prior history of arm pain or throwing injury. Additionally, participants were asked whether 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, including range of motion (ROM), strength, and stability testing, was performed by 1 of 2 orthopaedic surgeons (A.T.P., J.M.). 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 graded on a scale of 1 to 5 (5 being strongest). Shoulder instability was defined as a positive physical examination finding for any of the following: apprehension test, Jobe relocation test, 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 shoulder MRIs with a GE HDxt 3.0-T MRI scanner with the following sequences: axial T1-weighted (echo time [TE] 12-13 ms; repetition time [TR] 580-610 ms), axial inversion recovery (TE 45-50 ms; TR 3475-3500 ms), sagittal T2-weighted MERGE (multiple echo recombined gradient echo; TE 13.5-14 ms; TR 600-650 ms), coronal inversion recovery (TE 45-50 ms; TR 3475-3500 ms), and coronal T2-weighted fat-saturated (TE 64-70 ms; TR 2020-2070 ms). A single radiologist (J.D.) with a clinical focus on pediatric musculoskeletal imaging read all of the MRI images and was blinded as to any history of arm pain or the arm dominance of the player. The radiologist filled out a data sheet with dichotomized responses that allowed only positive or negative responses to the presence or absence of each abnormality. Bilateral shoulder ultrasonography was performed to assess humeral torsion, as previously described.17

Players who reported a history of shoulder pain or injury from baseball were compared with players who had a negative history in terms of clinical examination, questionnaire data, and MRI findings. The clinical examination and questionnaire data for players whose MRI results indicated an abnormality of their dominant arm (not present in the nondominant arm) were compared with the data for players whose MRI results did not indicate dominant-arm abnormality. These comparisons were made through use of chi-square test for categorical variables and analysis of variance (ANOVA) for interval data. The prevalence of particular findings (ie, a positive sulcus sign) was compared through use of $z$ ratio for the significance of the difference between 2 independent proportions. Dominant versus nondominant findings were compared by use of repeated-measures ANOVA or McNemar test. All interval data were checked for normality and homogeneity of variance prior to application of parametric statistics. Alpha was set at $P < .05$, and all analyses were performed through use of SPSS v12 (SPSS Inc).

RESULTS

The average age of the cohort was 11.4 years (range, 10-12 years) and all baseball players were boys. The majority of players were right-hand dominant (19/23, 83%). The participants had been playing on average for 6.4 years, and 43% were “year-round baseball players” (indicated they played at least 8 months per year); 22% (5/23) of the athletes played only baseball and no other sports. All participants played a variety of positions, but 65% of athletes listed themselves as pitchers and 26% listed themselves as catchers; 17% of the players had attended private baseball camps or used a private pitching or throwing coach. The majority of the athletes (83%) were aware that Little League baseball has pitching guidelines and stated that they had been compliant with these guidelines. The throwing history data are summarized in Table 1.

The baseline physical examination findings are recorded in Table 2. Shoulder motion was asymmetric between the dominant and nondominant arms, revealing decreased internal rotation of 7° in the dominant arm ($P < .01$). A greater than 10° deficit in internal rotation in the dominant arm was present in 26% of players. Otherwise, no
significant differences were identified between the dominant and nondominant arms with respect to elbow or shoulder stability, elbow ROM, carrying angle, or tenderness to palpation. The humeral torsion measurements revealed 5° of retrotorsion of the dominant arm compared with the nondominant arm.

In all, 83% of the players responded positively to having experienced arm pain from throwing, and 61% had previously experienced shoulder pain. None of these players had sought medical attention, received a formal diagnosis of their pain, or required any special treatment. A history of shoulder pain was associated with player position (pitchers) and more specifically with pitchers throwing curveballs or cutters, sliders, or sinkers ($P < .05$). Otherwise, a history of arm pain was not associated with players' demographics, their baseball history, or their physical examination findings.

Overall, 17 asymmetric MRI abnormalities were observed in the dominant shoulders of 12 players, representing 52% of the cohort, and 4 of these 12 players had multiple abnormalities. By comparison, the nondominant arm MRIs revealed only 2 abnormalities, representing a 6-fold higher rate of abnormality in the throwing arm of these athletes. The most common abnormality was edema or widening of the proximal humeral physis (5 players), followed by labral tear (4 players), partial rotator thickness tear (4 players), hypertrophy of the acromioclavicular joint capsule (2 players), subacromial bursitis (1 player), and cystic change of the greater tuberosity (1 player) (Figures 1-3). All of the abnormalities involving the rotator cuff were partial articular-sided tears measuring less than 50% of the thickness of the cuff. All involved the supraspinatus tendon, but 1 extended into the infraspinatus. The abnormalities involving the labrum included 2 anterosuperior labral tears, 1 anterior labral tear, and 1 posterosuperior labral tear. The 2 abnormal MRIs of the nondominant arm were both labral tears. The physeal width as measured by

### TABLE 1

| Player Responses to Baseball History Questionnaire | Player Response, n (%) |
|--------------------------------------------------|------------------------|
|                                                  | Primary positions      |
|                                                  | Pitching               | 8 (35) | 15 (65) |
|                                                  | Catching               | 17 (74) | 6 (26)  |
|                                                  | Infield or outfield    | 15 (65) | 8 (35)  |
|                                                  | Play year-round (≥8 months) | 13 (57) | 10 (43) |
|                                                  | Play on multiple teams during the year | 11 (48) | 12 (52) |
|                                                  | Private coaching        | 19 (83) | 4 (17)  |
|                                                  | Single-sport athlete    | 18 (78) | 5 (22)  |
|                                                  | Report baseball-related elbow or shoulder pain or injury | 4 (17) | 19 (83) |
|                                                  | Know the Little League throwing guidelines | 4 (17) | 19 (83) |
| pitchers only (n = 15)                           | Throw curveballs in past 12 months | 3 (20) | 12 (80) |
|                                                  | Throw sliders/cutters/sinkers in past 12 months | 12 (80) | 3 (20)  |
|                                                  | Age started organized pitching, average (range), y | 8.2 (7-10)  |

### TABLE 2

| Clinical Examination Findings$^a$ | Dominant | Nondominant | $P$ |
|----------------------------------|----------|-------------|-----|
| Shoulder internal rotation, deg, mean ± SD | 40 ± 15 | 47 ± 16 | <.001$^b$ |
| Shoulder external rotation, deg, mean ± SD | 89 ± 15 | 88 ± 13 | .25 |
| Shoulder tenderness to palpation | 0 (0) | 0 (0) | N/A$^c$ |
| Sulcus sign | 8 (43) | 9 (52) | .99 |
| Shoulder instability | 0 (0) | 0 (0) | N/A$^c$ |
| Impingement test | 0 (0) | 0 (0) | N/A$^c$ |
| O’Brien test | 3 (13) | 5 (22) | .5 |
| Rotator cuff weakness | 0 (0) | 0 (0) | N/A$^c$ |

$^a$At least 1 variable in each 2-way table upon which measures of association are computed is a constant. Values are presented as n (% positive) unless otherwise specified. N/A, not available.

$^b$Statistically significant difference ($P < .05$).

$^c$McNemar $P$ value cannot be calculated.
Radiographic abnormalities in the dominant arm of baseball players have been well documented in the literature. Asymptomatic rotator cuff tears and labral tears have been shown to be present in 21%-52% and 40%-48% of Major League Baseball pitchers, respectively. Imaging studies have also shown that degenerative changes of the acromioclavicular joint (21%-29%) and cystic changes of the humeral head (36%-76%) are common in these professional athletes. These radiographic abnormalities likely represent cumulative degenerative changes of the shoulder and have been associated with patient age and total innings pitched. From the literature, it is unclear at what point in an athlete's career these abnormalities develop. One study focusing on asymptomatic pitchers with an age range of 17 to 22 years showed a similar rate of rotator cuff tears (32%) and labral tears (42%) compared with the professional pitchers. To date, no study has looked at younger throwers, particularly those who are of Little League age. The results of the current study suggest that these changes are occurring much earlier than previously recognized. Historically, authors have suggested that the weak link in the young thrower's shoulder is the physis, which is prone to epiphysiodesis or Little League shoulder. While our study clearly shows that the physis is being stressed and altered in these young throwers, damage is also occurring to the labrum, rotator cuff, and acromioclavicular joint, representing structural abnormalities that might put these youth at increased risk of future pain, surgery, and disability. Clinicians need to be aware of the frequency of these radiographic abnormalities in baseball players, especially when interpreting the results of MRI scans obtained in this unique athletic population.

The results of the current study identified 2 risk factors for MRI abnormalities of the shoulder: year-round play and single-sport specialization. Previous studies have shown that shoulder pain is more closely associated with the cumulative number of hard throws over the course of a season than with the actual number of pitches in a game. Our data also suggest that MRI abnormalities are driven more by months of play than by position. In fact, 38% of nonpitchers in our study had an MRI abnormality of the shoulder. Year-round play was also recently shown to be the most significant risk factor for MRI abnormalities of the elbow in asymptomatic Little League players. Furthermore, the current study showed that 100% of “specialized” single-sport athletes with a focus on baseball had an abnormal MRI. This finding mirrors other recent data showing that the odds of an overuse injury are greater in athletes participating in a single sport year-round.

While the results of this study revealed that physeal changes including edema and widening of the proximal humeral physis are common, the results also demonstrated that torsional differences exist between the dominant and nondominant arms of these young throwers. Our cohort revealed a relatively symmetric change in shoulder ROM rotation of the dominant arm relative to the nondominant arm, with internal rotation decreasing by 7°. This compared similarly to ultrasonographic torsion measurements, which showed that the humerus was 5° retroverted in the dominant arm relative to the nondominant arm. This bony...
adaptation has been well documented in young baseball players as well as professional baseball pitchers and is believed to occur secondary to morphological 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. Some investigators have hypothesized that this process may be protective against shoulder injury, but this theory has yet to be confirmed. In contrast, glenohumeral internal rotation deficit secondary to contracture of the posterior capsule is not believed to be compensatory but is likely pathological and has been associated with shoulder and elbow injury in throwing athletes. In our cohort, 30% of the players had an internal rotation deficit of at least 10°. Interestingly, rates of MRI abnormalities were not significantly associated with loss of shoulder internal rotation, but our study was potentially underpowered to detect this difference.

Over the past decade, increased recognition of Little League throwing injuries has led to the development of several injury prevention and awareness campaigns, such as Sports Trauma and Overuse Prevention (STOP) and PitchSmart. Pitch count restrictions and mandatory rest days are now required of Little League pitchers. These rules have been effectively instituted in most Little Leagues in the United States. For example, in the case of our athletes, nearly all players were aware of the guidelines and reported never having violated these restrictions. A major limitation of programs such as STOP and PitchSmart, however, is that while they make 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, these recommendations are not enforced. In the current study, many athletes (43%) played baseball more than 8 months per year, 22% were single-sport “specialized” athletes, and 80% of pitchers threw curveballs, sliders, and sinkers. Until these larger issues are addressed, the epidemic of throwing injuries in the United States is unlikely to change.

This study had several limitations. 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 across the United States. Second, radiographic assessment of the shoulder was not performed because of radiation exposure concerns. It is unclear whether radiographs would have been more sensitive at picking up subtle bony changes about the physis. Third, patient histories, especially pertaining to pain and player position, were obtained retrospectively and thus are subject to recall bias; it is not clear when exactly the patients had experienced previous pain relative to their preseason MRI. Fourth, cost restraints limited the recruitment and imaging to only 23 athletes (46 shoulders). A larger cohort would have enabled further data analysis and risk stratification. Fifth, patient motivation for participating in the study was not known; patients with current pain or a history of pain potentially had more motivation to participate in the study. Other limitations of this study are that we included only male athletes, and we do not know the longer term implications of the noted abnormalities. These are important questions to address in future studies.

In conclusion, MRI abnormalities involving the shoulder are common in Little League baseball players, especially those who play baseball more than 8 months per year and who are single-sport athletes. While Little League guidelines potentially decrease injuries in pitchers, these guidelines require further refinement addressing year-round play, early sports specialization, pitch type, and pain. It is hoped that addressing these issues will decrease the high prevalence of arm pain and radiographic abnormalities in this throwing population.

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