[Sports Physical Therapy]

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Prevention of Overuse Injuries in Young Baseball Pitchers

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With millions of athletes participating in baseball in the United States annually, overuse injuries are common occurrences. Epidemiological studies, including surveys of orthopaedic surgeons, coaches, and athletes, indicate that injuries such as those to the ulnar collateral ligament are increasing in incidence. Many risk factors for throwing injuries have been proposed—including the immature skeleton, throwing mechanics, glenohumeral internal rotation deficit, pitch type, velocity, and counts—but little evidence is available to support the majority of these factors. Recent studies have shown that pitch volume and overuse are central factors that lead to shoulder and elbow injuries in the young throwing athlete. Pitching while fatigued and in spite of arm pain has also been implicated.

Keywords: youth pitchers' injuries; overuse; apophysitis; pitch counts

There are more than 12 million amateur baseball players in the United States.[20] Injuries due to participation in organized baseball are common occurrences and are frequent reasons for seeking evaluation from health care providers. Whereas significant injury may result from a directly thrown ball or collision with another player, overuse is the key factor implicated in most upper extremity injuries in the young throwing athlete. It is conceivable that recurrent "microinjuries" that begin in youth baseball may develop and blossom into serious, potentially career-ending injuries in high school, college, and at the professional levels.[3,20] By monitoring use in these young athletes, we may be able to prevent these injuries that surface later in a career. Maintaining proper biomechanics, monitoring pitch count limits, and resting between throwing outings are key strategies in avoiding many of these injuries.

Multiple epidemiological studies have been conducted to evaluate the incidence of throwing-related injuries in adolescents.[12,13] Included are surveys asking coaches and orthopaedic surgeons for recommendations and opinions regarding throwing injuries.[12] A survey of 300 young throwers in 1997 and 1998 regarding pitching practices and techniques attempted to identify risk factors for injury. More than half the respondents reported arm pain with different factors associated with shoulder and elbow pain, thus suggesting different causes.[13] In a 1999 study of nearly 500 pitchers aged 9-14 years, approximately 3500 postgame phone interviews were conducted focusing on risk factors for throwing arm pain. Fifty percent of the pitchers who were interviewed experienced elbow or shoulder pain during the season. There was a significant association between (1) the number of pitches thrown during a game and the season and (2) the rate of shoulder and elbow pain. The curveball and slider were associated with an increased risk of shoulder and elbow pain.

Ulnar collateral ligament injuries of the elbow are increasing in incidence.[18] In one major center, ulnar collateral ligament reconstructions were performed approximately 5 times per year between 1995 and 2000, jumping in 2007 to approximately 50 procedures in throwers aged 18 years old and younger.[18] This increase may be due to a heightened awareness of the injury, improvements in surgical outcomes, excessive pitch counts, or pitching while fatigued.

In a retrospective analysis (1995-2000), Petty et al[18] reported 31 ulnar collateral ligament reconstructions in 27 mature male high school athletes (baseball players). Specifically, there were 24 pitchers and 3 catchers with an average age of 17.4 years (range, 15.9-19.1 years) with medial elbow pain in the arm-cocking or early acceleration phase. All 27 athletes demonstrated pain with dynamic valgus stress testing; 88% showed a tear (partial or complete) or edematous ligament with high signal intensity on magnetic resonance imaging. Many of these athletes had risk factors (average, 3), including velocity of 80 miles per hour

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Table 1. Ossification centers of the elbow.[a]

Ossification Center	Age of Appearance, y
Capitellum	1
Radius	3
Medial epicondyle	5
Trochlea	7
Olecranon	9
Lateral epicondyle	11

[a]Reprinted with permission from Dr Marshall Crowther.

or more. Eighty-five percent reported overuse (year-round throwing, seasonal or event). Overuse was noted as the most significant risk factor for ulnar collateral ligament injuries in adolescent throwers. Repetitive microtrauma and inadequate tissue recuperation may lead to weakness in the ligament and ultimate failure.[3,16]

Epidemiological studies and personal experience indicate that the incidence of throwing-related injuries in adolescents is on the rise for many reasons. The immature skeleton of a young thrower responds differently than a mature skeleton to the stresses of throwing. At the elbow, 6 ossification centers (Table 1) appear between ages 2 and 11 years. Because these centers do not fuse until the ages of 13 to 17 years, these open physes are common sites of injury.[8,10] When injury occurs on the medial elbow of a skeletally immature athlete, it is often at the physis. However, upon closure of the physis, the ulnar collateral ligament is more likely to be injured (unpublished data, M. Crowther, 2007).[8]

Proper throwing biomechanics are important for safe pitching practices.[1,3,11] The most common injury pattern is valgus extension overload.[8] In the early phases of throwing, the medial elbow endures a significant tensile force, whereas the lateral elbow experiences a compressive force (see Figure 1). The posterior structures, such as the olecranon, are subject to stress during the full extension that occurs in the latter stages of throwing. Fleisig et al[7] evaluated the biomechanics of different levels of development in pitchers (youth, high school, college, and professional) and found that the pitcher can learn proper mechanics at a young age. Similarly, abnormal scapular motion on the thoracic wall may contribute to shoulder problems. Normally, the scapula rotates upward and tilts posteriorly during arm elevation. Poor coordination of these movements may contribute to an impingement rotator cuff injury.[9]

Another topic of significant debate is the influence of pitch type, frequency, and pitch counts. Recent studies have suggested that pitch volume (pitch count and frequency) lead to shoulder and elbow injuries in the young throwing athlete.[6,11,13] Dun et al[6] compared the mechanics of youth pitchers throwing the fastball, curveball, and change-up. They found that shoulder internal rotation torque, varus elbow torque, and proximal force were significantly less for the curveball than for the fastball, which suggests that the curveball might not be more harmful than the fastball for the youth pitcher. Although adequate rest between competitions is recommended, young pitchers are still encouraged to throw in other settings (playing catch at home, playing other positions, etc) to strengthen the arm and body.[2]

High velocity is also a risk factor for pitchers. Cadaveric studies of the ulnar collateral ligament have shown that the upper limit of torque that the ligament can withstand before failure is around 32 N·m[5,14] which is approaching 80 miles per hour (unpublished data, M. Crowther, 2007).[13,17] These high-velocity throwers were more likely to be overused, recruited to more leagues, and pursued early to accelerate their development.

Glenohumeral internal rotation deficit has also been proposed as a risk factor for shoulder injury, specifically, the rotator cuff and labrum.[4] The chronic distractive forces experienced by the posterior/inferior capsule during follow-through may result in posterior capsular contracture. Clabbers et al[4] found that a 40% plication of the posterior/inferior and posterior capsule in cadaveric specimens resulted in a trend for superior-posterior migration of the humeral head in the late cocking phase of throwing.

Nakamizo et al[15] evaluated 25 male Little League pitchers (11.4 ± 0.4 years old) to confirm the presence of glenohumeral internal rotation deficit. The youth pitchers underwent examination with a motion capture system measuring internal and external rotation in the dominant and nondominant arms. Twenty pitchers had loss of internal rotation, with 10 having greater than 20° loss. External rotation differences in the glenohumeral internal rotation deficit group were not clinically significant. Results suggest that glenohumeral internal rotation deficit can occur before the development of increased external rotation in young pitchers.

K. Wilk and L. Macrina (unpublished data, July 2008) investigated the association among glenohumeral internal rotation deficit, a difference in total rotational range of motion, and shoulder injuries. Passive range of motion measurements were obtained each year on both shoulders of 122 pitchers, 41 of whom had a significant loss of internal range of motion (18.7°). Participation in multiple leagues, year-round baseball, showcases, inadequate rest, and improper strength and conditioning were all recognized as risk factors.

With millions of young athletes participating in competitive baseball annually, it is essential that physicians, coaches, parents, and the athletes themselves become aware of potential overuse injuries. Monitoring for the signs or symptoms of common overuse injuries may prompt diagnosis and prevent further deterioration and injury. Abiding by recommendations proposed from the various organizations and research institutes

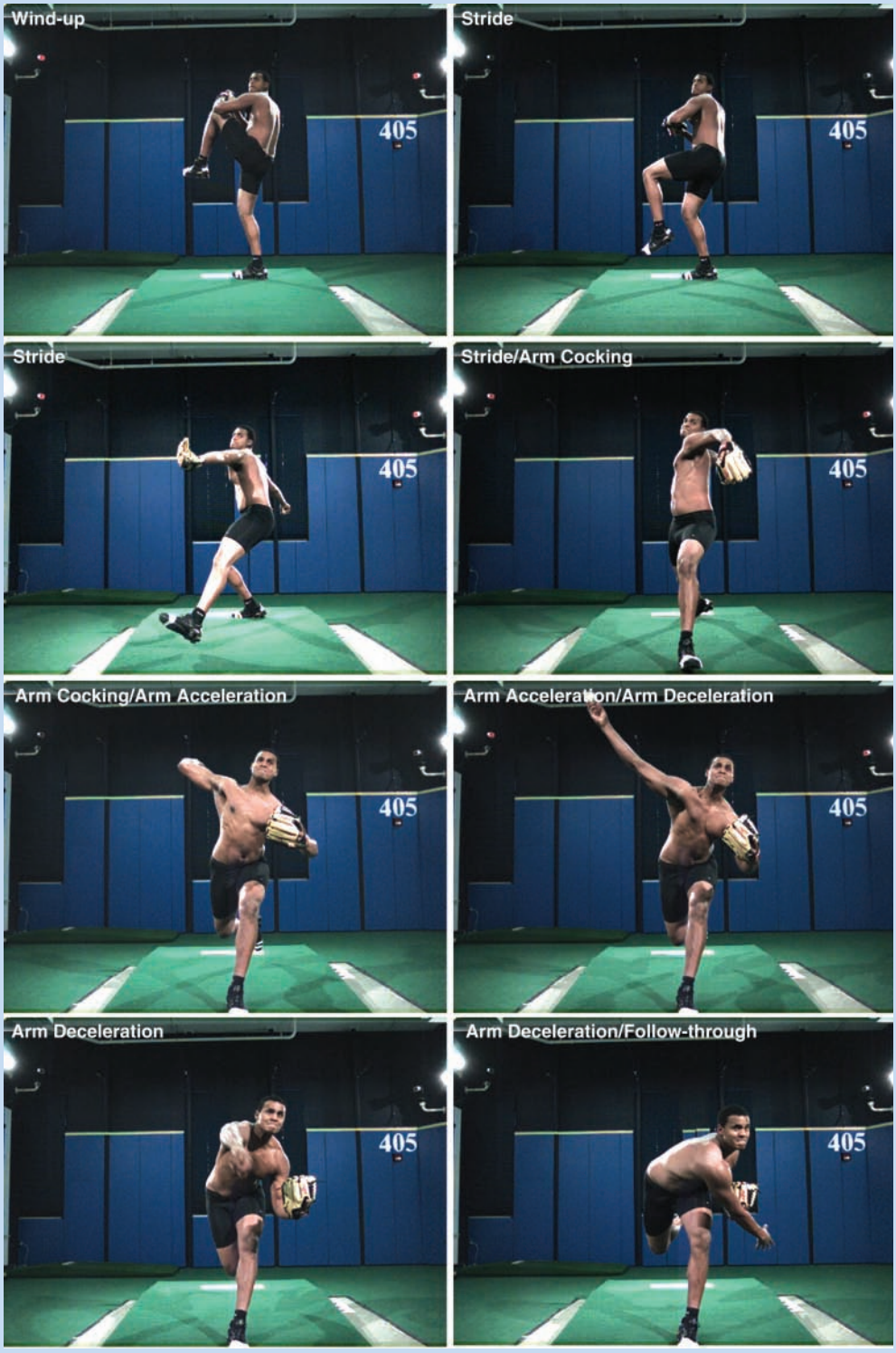

Figure 1. Pictorial series of normal pitching mechanics. Photos © American Sports Medicine Institute. Reprinted with permission. Wind-up: from first movement to peak lead knee height. Stride: from lead knee height to stride foot contact. Arm cocking: from stride foot contact to maximum shoulder external rotation. Arm acceleration: from maximum shoulder external rotation to ball release. Arm deceleration and follow-through: from ball release to the end of the throwing motion.

Table 2. Minimum number of pitches thrown and recommended rest between outings (mean ± standard deviation).[a]

Age, y	1 Day	2 Days	3 Days	4 Days
8-10	21 ± 18	34 ± 16	43 ± 16	51 ± 19
11-12	27 ± 20	35 ± 20	55 ± 23	58 ± 18
13-14	30 ± 22	36 ± 21	56 ± 20	70 ± 20
15-16	25 ± 20	38 ± 23	62 ± 23	77 ± 20
17-18	27 ± 22	45 ± 25	62 ± 21	89 ± 22

[a]Strength of recommendation grade C (consensus, disease-oriented evidence, usual practice, expert opinion, or case series for studies of diagnosis, treatment, prevention, or screening). Reprinted with permission from USA Baseball.

will help decrease the incidence of these injuries. With these measures, the young thrower can continue to participate and compete at the highest level possible. The following safeguards have been recommended for preventing youth throwing injuries[18]:

- Breaking pitches should not be thrown in competition until bones have matured, as indicated by puberty. A rule of thumb is that a player should not throw breaking balls until he is shaving regularly.
- Young pitchers should develop proper mechanics and participate in year-round physical conditioning programs.
- Pitchers should not be allowed to return to the mound in a game in which they have already been removed as the pitcher. In addition, no intense pitching practice should take place after the game.
- Showcases are discouraged.
- Pitchers are discouraged from pitching in more than one league if multiple leagues overlap within a season.
- Pitchers should not compete in baseball for more than 9 months in any given year. At least 3 months of arm rest from drills or any other stressful overhead activities (quarterbacking, competitive swimming, playing softball, etc) is highly recommended.
- Specific rest periods between outings are recommended on the basis of age and quantity of pitches (Table 2).[2]

In addition to these key strategies for the prevention of injury, consideration must be given for return to play after injury. Regaining motion and strength are important factors during rehabilitation after injury or surgery. Using an interval throwing program will help an athlete return to activity and thereby minimize the chance of reinjury.

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