Prevention of Elbow Injuries in Youth Baseball Pitchers

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FLEISIG, G.S., A. WEBER, N. HASSELL, and J.R. ANDREWS. Prevention of elbow injuries in youth baseball pitchers. Curr. Sports Med. Rep., Vol. 8, No. 5, pp. 250-254, 2009. There is concern among sports medicine practitioners that the number of youth baseball pitchers with elbow injuries appears to be increasing. Research points to overuse as the principle risk factor. The risk of elbow 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 out of a year, or with arm fatigue are several times more likely to require elbow surgery. Poor pitching mechanics also appear to contribute to injury risk. Existing research does not show a significant correlation between curveballs and injury. Adults should help youth pitchers avoid fatigue, overuse, and improper mechanics. If elbow pain develops, the youth pitcher should be evaluated by a sports medicine physician.

INTRODUCTION

A perceived increase in youth sports injuries has received much attention in the mass media in recent years. This has prompted an examination of the mechanical and epidemiological risk factors associated with youth sports injuries. If an injury is noted early enough in its natural history, conservative measures such as rest, cryotherapy, antiinflammatory medications, and physical therapy can be used. However, in some cases, if the damage progresses, surgical treatment may be the only option if the athlete is to return to his or her previous level of competition (1,2,14).

The number of ulnar collateral ligament (UCL) reconstructions (“Tommy John” surgeries) appears to be increasing, especially in young baseball pitchers (8,20). For example, at our medical center there were approximately two UCL reconstructions performed per year on high-school-aged pitchers during the 1990s, but approximately 30 per year in recent years. What is most alarming is the percent of young patients. In the 5-yr period from 1994 to 1998, only 7% (9 of 116 total patients) of the UCL reconstructions performed on baseball pitchers at our center were high-school-aged or younger. During the next 5 yr (1999-2003), high-school-aged and younger patients accounted for 21% (110/425) of the UCL reconstructions on baseball pitchers. During the most recent 5-yr span (2004-2008), high-school-aged and younger patients accounted for 26% (179/512). A year-by-year breakdown of these numbers is shown in Table 1. The increase in the number of surgeries and percent of surgeries in young baseball pitchers may represent a true increase in injury incidence, improved diagnostics, or a combination of these two factors (14).

While the statistics for UCL surgery are convincing, what is perhaps more concerning is that they likely underrepresent the actual problem. Baseball pitching injuries are the result of accumulated microtrauma from repetition. UCL ruptures in adult pitchers may be the result of microtears initiated in earlier years. In fact, 28% of all youth baseball pitchers experience elbow pain during the season (13).

INJURY MECHANISM

Biomechanical research has shown that maximal elbow varus torque is produced when the throwing arm is cocked back into maximum shoulder external rotation (Fig.). At this instant, the elbow must terminate backward rotation of the forearm and initiate the forearm’s forward rotation. A 12-yr-old pitcher produces approximately 30 Nm of varus torque when throwing a fastball (3,6,18,22). Tension in the UCL provides approximately 50% of the maximum varus torque in this position (5,16). Repetition of this tensile load can lead to partial or complete tear of the UCL. Although younger pitchers produce significantly less torque than adults

<table>
<thead>
<tr>
<th>Year</th>
<th>Youth and High School</th>
<th>TOTAL</th>
<th>% Youth and High School</th>
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<tr>
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<td>0</td>
<td>6</td>
<td>0%</td>
</tr>
<tr>
<td>1995</td>
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<td>21</td>
<td>10%</td>
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<td>125</td>
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</tr>
<tr>
<td>2008</td>
<td>28</td>
<td>89</td>
<td>31%</td>
</tr>
<tr>
<td>TOTAL</td>
<td>298</td>
<td>1338</td>
<td>22%</td>
</tr>
</tbody>
</table>

(6), the youth pitcher has more compliant connective tissue, open epiphyses, and underdeveloped muscles (10). Thus in the youth pitcher, tensile load in the UCL can lead to bony avulsion at a growth plate near the origin or insertion of the anterior bundle of the UCL.

Varus torque also can lead to lateral elbow injury. Approximately one third of varus torque is produced by compression between the radial head and humeral capitellum (5). This can lead to osteochondritis dissecans, osteochondral chip fractures, or avascular necrosis.

From the arm-cocked position, the elbow rapidly extends. The combination of elbow varus torque and elbow extension velocity can lead to impingement in the posteromedial elbow (5). Repetitive pitching can result in osteophytes, chondromalacia, and loose bodies at the posteromedial aspect of the olecranon tip.

OVERUSE

The scientific literature points to four main risk factors for youth baseball elbow injury: number of pitches thrown, pitching mechanics, pitch type, and physical condition of the player (3). Of these four factors, the number of pitches thrown has the strongest correlation to youth pitching injuries (11).

During the 1999 spring season, USA Baseball commissioned Lyman et al. to conduct a prospective cohort study. This study followed 476 youth baseball pitchers (9–14 yr old) playing at 15 parks throughout the state of Alabama (13). Pitch counts were recorded for each pitcher during each game throughout the entire season. In addition, each pitcher was interviewed by telephone the day after each game to determine whether any arm pain had developed. Of all pitching appearances, 7% resulted in elbow pain, and 28% of the pitchers had elbow pain at least once during the season. The risk of elbow pain increased with the number of pitches thrown. For example, compared with a low-pitch-count outing (fewer than 25 pitches), a pitcher was 21% more likely to sustain elbow pain when throwing between 50 and 74 pitches. This increased to 35% when between 75 and 99 pitches were thrown in a game. The risk of elbow pain also increased with cumulative pitch counts during the season. Compared with the first 200 pitches during the season, a pitcher had a 63% increased risk of elbow pain in a game when the season pitch count reached between 200 and 400, but a 234% increased risk in a game when the season pitch count was between 600 and 800.

Olsen et al. conducted a retrospective study, comparing adolescent pitchers (aged 14–20 yr) requiring surgery with a control group comprising age-matched healthy pitchers (19). The elbow surgery group was significantly taller and heavier than the control group and threw faster. There were no differences in number of years pitching or age began pitching between the two groups. Based upon their recollection of their last seasons, the elbow surgery group pitched competitively more months per year and more pitches per game than the control group did. Multivariate analysis revealed significant risk factors. Adolescent pitchers who pitched competitively more than 8 months out of a year were approximately five times (5.05 odds ratio (OR) (1.39–18.32)) more likely to sustain an elbow or shoulder injury. Individuals who averaged more than 85 pitches per appearance were at an increased injury risk of approximately fourfold (3.83 OR (1.36–10.77)). Most startling was the fact that those who had pitched regularly with arm fatigue were 36 times more likely to sustain an injury.

In 2006, USA Baseball published pitching safety guidelines. Little League Baseball enacted pitch limit regulations the following year. The guidelines are stratified for different age groups and require a set amount of rest based on the number of pitches thrown (Table 2). While there has not been enough time to determine the effectiveness of pitch counts, initial feedback has been encouraging. Little League sent a survey to Little League coaches throughout the United States, and the results showed that 7% of pitchers had elbow pain at least once during the season. The risk of elbow pain increased with the number of pitches thrown. For example, compared with a low-pitch-count outing (fewer than 25 pitches), a pitcher was 21% more likely to sustain elbow pain when throwing between 50 and 74 pitches. This increased to 35% when between 75 and 99 pitches were thrown in a game. The risk of elbow pain also increased with cumulative pitch counts during the season. Compared with the first 200 pitches during the season, a pitcher had a 63% increased risk of elbow pain in a game when the season pitch count reached between 200 and 400, but a 234% increased risk in a game when the season pitch count was between 600 and 800.

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Figure. Baseball pitcher at the instant of maximum shoulder external rotation.

Volume 8 • Number 5 • September/October 2009

Prevention of Elbow Injuries in Youth Baseball Pitchers 251
The entries in bold type indicate regulations governing ages 7–16.
N/A = not applicable.

States after the 2007 spring season, and 1777 of them responded (Little League Baseball, email correspondence, 2007). Nearly half of the respondents (46%) felt that there were fewer sore arms in the first year with pitch counts. The implementation of pitch counts led to more players sharing the pitching load. This was viewed both positively and negatively by the coaches. Because of the pitch count limits, 60% of the respondents indicated it was difficult to identify enough pitchers, but 70% felt that this led to the development of more pitchers. Our belief is that the distribution of the pitch workload among more youth players is a good thing. Another issue raised on the survey results was concern about the combination of pitching and catching. Approximately half (52%) of the respondents were opposed to one player playing both of these positions in the same game. In 2008, Little League added a rule prohibiting a pitcher removed from the mound from playing catcher for the rest of the day. Although there are no data on this at this time, there is reason to be concerned about the combination of pitching and catching.

The issue of pitching overuse goes well beyond Little League. That is because youth baseball today includes not only teams from schools and organizations like Little League, but also independent and travel teams. Many independent and travel teams have no rules restricting pitch counts, inning limits, or days of rest. Certainly there are no rules restricting the cumulative amount of pitching a youth pitcher can do among teams from various leagues or organizations. Youth who excel at baseball pitching these days have the opportunity to pitch more many games and pitches than in previous generations past. Some young pitchers — especially those in warmer states — now can play organized baseball year-round. However, more is not always better. With increasing demand on youth athletes to pitch more, there is less time for repair of bony and soft tissues in the elbow. Sustained insult also is more likely when elbow pain is misinterpreted and the injured athlete is sent back on the field. Muscle soreness is a normal response to strenuous activity, but when a high demand to perform is placed on youth athletes, genuine joint pain indicative of injury can be discounted wrongly. Further activity is deleterious to the player and can have long-term detrimental effects (11).

The importance of overuse as the chief risk factor for injury in youth baseball players cannot be understated. No matter how poor a pitcher’s mechanics or how deleterious a certain variety of pitches may be, injury is the result of repeated insult to the elbow joint and never one single throw to the plate. Even incidents when a pitcher feels a “pop” likely are the final outward manifestations of recurrent abuse. Conversely, young players who are not as talented are “weeded out” and do not have as many opportunities. This situation is not limited to baseball. Our impression is that in past generations, most children engaged in a reasonable amount of sports participation; now, there are many children who do not play enough sports, and a smaller “elite” group of children who participate too much in one particular sport.

Today’s youth pitcher and the adults around him or her must find a reasonable balance between too much and too little. As the data show, high pitch counts and long seasons increase the risk of elbow injury. However, a young pitcher must pitch enough to develop the technique, strength, and experience needed to enjoy the game and improve his or her skill. The bottom line is that even with all of the advances in medicine and research, the best tools for prevention of elbow injuries are common sense, awareness of pitch count, and avoiding (physical and mental) fatigue.

**PITCH TYPE**

There is a long-standing belief that breaking pitches are especially deleterious to young pitchers. This conviction is based on the principle that to impart the necessary spin to a ball to cause a break, the pitcher must put his or her arm in a position that increases strain on the elbow (23). While no increase in risk has been noted in collegiate pitchers for different pitch types, it is thought that immature anatomy and poor mechanics of the youth baseball player makes him or her susceptible to injury.

The prospective youth study by Lyman et al. found no correlation between throwing a curveball and increased risk of elbow pain (13). However, youth pitchers who threw a slider had an 86% increased risk of elbow pain. When Olsen et al. compared adolescent pitchers with elbow surgery to a healthy control group, they found no significant difference in how old the pitch groups were when they began throwing breaking balls (19).

Dun et al. (3) conducted a biomechanical study comparing the fastball, curveball, and change-up in youth pitchers (11–14 yr old). As expected, the fastball had greater forearm supination than the fastball. However, elbow varus torque
was significantly less in the curveball (31.6 ± 15.2 Nm) than
in the fastball (34.8 ± 15.4 Nm). Nissen et al. conducted a
similar study using slightly older pitchers (14–18 yr old), and
also found significantly less varus torque in the curveball
(54.1 ± 16.1 Nm) than fastball (59.6 ± 16.3 Nm) (17). Fur-
ther, a cadaveric study showed that changes in supination did
not affect tension in the UCL during elbow varus torque (21).

Thus, clinical and biomechanical data do not support the
theory that throwing curveballs increases the risk of elbow
injury for youth pitchers. We now believe that the reputation
of the curveball being dangerous has come from misleading
anecdotal evidence. In other words, young pitchers needing
elbow surgery may report a history of throwing curveballs,
but these athletes probably were injured because they were
the successful, hard-throwing pitchers and pitched too much.
When the parent or coach of a young player asks whether
the youth should throw curveballs, the instructor or medical
professional should first assess the adult’s motives for asking
the question. The use of the curveball might not be the risk
itself; the issue might be an overenthusiastic adult who has a
child throwing too much. Suggested recommendations for
the skill progression of a young baseball player are as follows:

1. Basic skills of baseball, including throwing, catching,
hitting, and running.
2. Fastball pitching mechanics.
3. Changeup pitching mechanics.

Thus, the best measure for when a young pitcher is ready
to add a curveball might be when good mechanics for the
fastball and changeup have been mastered.

MECHANICAL FLAWS

Numerous biomechanical studies have quantified the fast-
ball biomechanics of adult baseball pitchers. In 1999, Fleisig
et al. compared biomechanics among youth, high school,
college, and professional pitchers (6). The study found vir-
tually no difference among the competition levels for the
joint angle and timing parameters, but significant differences
in joint velocities, forces, and torques. Peak angular velocity
for pelvis rotation, upper trunk rotation, elbow extension,
and shoulder internal rotation were greater for the adult
pitchers (college and professional) than for the adolescent
levels (youth and high school). Elbow and shoulder kinetic
parameters increased with each higher competition level. A
recent study compared the within-pitcher variability among
fastball biomechanics at five levels (youth, high school, col-
lege, minor league, and Major League Baseball) (7). This
study found an increased variability in position and velocity
parameters for younger pitchers. There were no significant
differences in variability for timing and kinetic parameters
among the different levels.

Four recent studies have quantified fastball biomechanics
exclusively for the youth pitcher (approximately 12 yr old)
(3,10,18,22). All four of these studies describe the need to
help prevent elbow injuries in youth pitchers. Like an adult
pitcher, the youth pitcher swings his arms apart and up
during the leg stride. At the time of front foot contact, the

STRENGTH AND CONDITIONING

The goals of physical conditioning for young baseball
players include coordination, athleticism, and general fitness.
If a young baseball player does want to participate in a
physical conditioning program, it is recommended that a
functional movement screening and training program is
chosen. Functional movement screening has been correlated
to injury risk in professional football players (12) and may be
related to injury risk with younger athletes as well. A func-
tional movement training program includes not only strength
training but also flexibility, range of motion, coordination,
balance, and proprioception (12). However, a youth pitcher who is relatively fit and athletic may not need a strength and conditioning program. Biomechanical data suggest that good mechanics is a higher priority than strength for the youth pitcher; more focus should be added to physical conditioning after the body matures (6,7). For a youth pitcher with relatively good fitness, playing baseball, playing other sports and activities, and participating in physical education at school should be a sufficient physical fitness program.

CONCLUSION

With the rise in elbow injuries in youth baseball pitchers, the adult community needs to take steps to prevent these injuries. Research points to overuse as the principle risk factor. Poor pitching mechanics also contribute to injury risk. Throwing curveballs has also been suggested as a risk factor, but the existing research does not support this concern. Another suggested risk factor is poor physical fitness. Thus, the recommendations for preventing elbow injuries in youth baseball pitchers are as follows:

1. Watch and respond to signs of fatigue. If a youth pitcher complains of fatigue or looks fatigued, let him or her rest from pitching and other throwing.
2. Youth pitchers should not pitch competitively in more than 8 months in any 12-month period.
3. Follow limits for pitch counts and days of rest (example limits are shown in Table 2).
4. Youth pitchers should avoid pitching on multiple teams with overlapping seasons.
5. Youth pitchers should learn good throwing mechanics as soon as possible. The first steps should be to learn, in order: 1) basic throwing, 2) fastball pitching, and 3) changeup pitching.
6. Avoid using radar guns.
7. A pitcher should not also be a catcher for his or her team. The pitcher-catcher combination results in many throws and may increase the risk of injury.
8. If a pitcher complains of pain in his or her elbow, get an evaluation from a sports medicine physician.
9. Inspire youth pitchers to have fun playing baseball and other sports. Participation and enjoyment of various physical activities will increase the youth’s athleticism and interest in sports.

References
