

Prevention of Arm Injury in Youth Baseball Pitchers

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TARGET AUDIENCE	CME INFORMATION	CREDIT
<p>The March/April Youth Baseball Pitchers feature article is intended for all physicians that educate youth baseball players, parents, and coaches about injury prevention. Particularly, this includes primary care physicians, pediatricians, and orthopedic surgeons.</p>	<p>The LSMS Educational and Research Foundation designates this educational activity for a maximum of one (1) <i>AMA PRA Category 1 Credit</i>TM. Physicians should only claim credit commensurate with the extent of their participation in the activity.</p>	
<p>EDUCATIONAL OBJECTIVES</p> <p>After reading this article, the healthcare provider should be able to identify risk factors and know how to reduce likelihood of youth baseball pitcher arm injury and surgery. Estimated time to complete this activity is one (1) hour.</p>	<p>DISCLOSURE</p> <p>Drs. EK Kerut, DG Kerut, Fleisig, and Andrews have nothing to disclose.</p>	
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The advent of youth year-round baseball has come with an increased incidence of pitching related injury and surgery, most notably involving the shoulder and elbow (ulnar collateral ligament). These injuries become evident in high school and college, but begin at the youth level.

Several studies have identified baseball pitching risk factors during youth that increase likelihood for injury and surgery in subsequent years. Based on these studies, the USA Baseball Medical & Safety Advisory Committee has published guidelines for pitching that include limits on pitch count and pitches per week and season as well as recommendations for number of rest days between pitching. Also, recommendations include the restriction of breaking balls prior to puberty, the importance of instruction for proper pitching mechanics as early as possible in development, and at least three months of rest after a season.

This review is intended to help guide primary care physicians and pediatricians when discussing youth pitching and injury prevention with parents and coaches.

INTRODUCTION

When the senior author (JRA) grew up in Louisiana, baseball was a seasonal sport. Now it is a year-round activity, with organizations sponsoring tournaments throughout the year. With this has come an increase in youth pitching related injury, notably involving the shoulder and elbow ulnar collateral ligament (UCL).^{1,2} Correspondingly, surgery for shoulder and UCL injury ("Tommy John" procedure) has increased significantly in high school pitchers over the past ten years.³ These injuries that become evident in high school and college are believed to begin at the youth level, from cumulative recurrent microtrauma.^{2,4,5}

DISCUSSION

The USA Baseball Medical & Safety Advisory Committee (part of the United States Olympic Committee) recognized a need to improve understanding of factors associated with pitching related injuries. In 1999 it commissioned the Birmingham based American Sports Medicine Institute (ASMI) to perform a prospective study of youth players throughout Alabama.² Pitchers (n=476) were evaluated at baseline with demographics and baseball related information, as well as to identify pitchers with a prior history of dominant arm problems. Additionally, the ASMI videotaped 172 of these to evaluate pitching

pitching biomechanics. Throughout the season, a log of game pitch count, season cumulative count, and pitch type (fastball, change-up, curveball, and slider) was made. While upper extremity muscular soreness is a normal part of pitcher development, joint pain is not, and it is believed to be a warning sign of developing overuse injury.^{2,6-9} Outcomes of the study were therefore postgame elbow or shoulder pain. In the age group 9 to 14 years, a high pitch count and also breaking pitches (curveball, slider) were significantly associated with an increased risk of elbow and shoulder pain. The study was statistically underpowered to show a significant risk of joint pain related to pitching mechanics. An increasing pitch count and cumulative count through the season was linearly associated with an increased risk of joint pain. It was therefore recommended that not only should pitch count be limited but season cumulative pitches as well. While this study could not show a relation of injury with proper mechanics (limited sample size and difficult video collection/analysis method), it has been demonstrated that

Table 1. Comparison between the control group of pitchers and pitchers that required reparative surgery.¹⁸

Variable	Control n=45	Reparative Surgery n=95
Months Pitched/Year	5.5 ± 2.3	7.9 ± 2.5
Games Pitched/Year	18.6 ± 13.0	28.8 ± 14.7
Innings Pitched/Game	4.3 ± 1.7	5.6 ± 1.4
Pitches/Game	66.2 ± 25.3	87.8 ± 21.8
Pitches/Year	1269 ± 1040	2563 ± 1506

similar mechanics are used by successful pitchers, no matter the age and skill level.^{2,7,10}

A retrospective study of high school pitchers with UCL injury and reparative surgery (n=27) from a single sports orthopedic surgical center found overuse to be the predominant risk factor for UCL injury. Subsequent studies have also suggested that high pitching velocity (83 mph and greater in high school pitchers)³ and pitching while fatigued¹¹⁻¹² are potential risk factors for UCL injury. In addition, multiple prior studies and reports recommend teaching proper pitching mechanics for injury prevention.^{2-3,13-17}

Based on these reports, a case control study was performed comparing adolescent pitchers (ages 14 to 20 years)(n = 95) who developed pitching related injury (elbow or shoulder injury with subsequent surgical repair in the dominant arm) to active high school and college pitchers with no history of injury (n = 45).¹⁸

Compared to controls, the group that required reconstructive surgery had pitched more months/year, games/year, innings/game, pitches/game, and pitches/year (Table 1). In addition, the injured group pitched with

Table 2. USA Baseball Medical & Safety Advisory Committee recommendations for limits with youth pitchers (modified with permission).^{20, 21}

Age in years	Pitches/ Game	Pitches/ Week	Pitches/ Season	Pitches/ Year
9-10	50	75	1000	2000
11-12	75	100	1000	3000
13-14	75	125	1000	3000
15-16	90	2 games/ week		
17-18	105	2 games/ week		

higher velocity and more often with arm pain and fatigue. Multivariate analysis identified the most significant risk factors for high school and college pitcher injury and need for surgery as: an increased risk of 500% for pitching greater than 8 months per year, 400% for pitching greater than 80 pitches per game, and over 250% for a fastball greater than 85 mph. When regularly pitching despite arm fatigue, the risk for injury requiring surgery increased 3600%. This one factor - fatigue - had the strongest correlation with subsequent arm surgery.

Although past data have demonstrated a risk of arm pain in younger pitchers (ages 9 – 14) who throw breaking balls (curveball),² this case controlled study did not show a correlation between age at which a curveball was first thrown and risk of subsequent surgery. However, numbers of pitchers for both groups were relatively low for those who threw curveballs before reaching puberty. Subsequently, a recent analysis of biomechanics of various pitch types suggests that the curveball may not be more harmful than the fastball for youth pitchers. The greatest mechanical stresses on the elbow and shoulder were found to be the fastball, followed by the curveball, and least of all the

Table 3. USA Baseball Medical & Safety Advisory Committee recommendations for days of rest after a pitching event (modified with permission).¹

Age in years	1 Day Rest	2 Days Rest	3 Days Rest	4 Days Rest
9-10	21-33 pitches	34-42 pitches	43-50 pitches	51 + pitches
11-12	27-34 pitches	35-54 pitches	55-57 pitches	58 + pitches
13-14	30-35 pitches	36-55 pitches	56-69 pitches	70 + pitches
15-16	30-39 pitches	40-59 pitches	60-79 pitches	80 + pitches
17-18	30-39 pitches	40-59 pitches	60-89 pitches	90 + pitches

change-up.¹⁹ These data are consistent with findings that suggest amount of pitching as a stronger risk factor for injury than pitch type.

Based on available data, the USA Baseball Medical & Safety Advisory Committee has published recommendations to reduce risk of injury and maximize a young player's chance for advancement to higher levels of baseball competition without injury.²⁰⁻²¹

Limits on pitching for youth (Table II) and recommendations for rest days after a pitching event (Table III) reduce the risk of subsequent injury in later adolescent and teenage years.^{3, 20-23}

In addition to the Guidelines (Tables II & III), the Committee made the following general recommendations for youth pitchers:²⁰⁻²¹

1. Do not throw breaking pitches (curveballs, sliders) until puberty (about age 13). Instead, a youth pitcher should focus on a fastball and change-up, and also pitch control.²
2. Proper pitching mechanics are important as early as possible in the development of the pitcher (7). Year-round physical conditioning should be employed as the body develops.
3. Pitchers are discouraged from pitching for more than one team in a season.
4. For at least three months a year, a pitcher should not play any baseball or perform throwing drills. In addition, any overhead activity (football quarterback, competitive swimming, javelin throwing) should be avoided during that period of time.
5. A pitcher should not return to the pitching mound in a game after being removed. Additionally, pitching practice after a pitched game is to be avoided.

SUMMARY AND CONCLUSION

The advent of year-round baseball has brought about an increased incidence of youth pitching related injury and surgery, most notably involving the shoulder and ulnar collateral ligament (Tommy John operation). These injuries become evident in high school and college, but begin at the youth level. The most significant studies that identified youth risk factors associated with subsequent injury are discussed in this article.

USA Baseball Medical & Safety Advisory Committee Guidelines and recommendations are provided to help primary care physicians and pediatricians when discussing injury prevention with parents and coaches of youth pitchers. Although these Guidelines are useful, there is no universal pitch count "right number," as each child athlete is different. The point is that youth baseball players should adhere to some pitching limits, from USA Baseball or another organization.

The biggest risk factor for subsequent injury appears to be arm fatigue. Pitchers who frequently pitch with arm fatigue are much more likely to develop future injuries requiring surgery. Hence, coaches need to listen to their

young pitchers when they complain of arm fatigue or pain.

While youth baseball coaches should be aware of pitch counts and the warning signs of arm fatigue and pain, injury does not become manifest until years later. As child advocates, physicians need to educate coaches, parents and youth athletes about injury prevention.

REFERENCES

1. Andrews JR, Fleisig GS. How many pitches should I allow my child to throw? *USA Baseball News* April, 1996:5.
2. Lyman S, Fleisig GS, Andrews JR, et al. Effect of pitch type, pitch count, and pitching mechanics on risk of elbow and shoulder pain in youth baseball pitchers. *Am J Sports Med* 2002; 30:463-468.
3. Petty DH, Andrews JR, Fleisig GS, et al. Ulnar collateral ligament reconstruction in high school baseball players: clinical results and injury risk factors. *Am J Sports Med* 2004; 32:1158-1164.
4. Andrews JR, Fleisig GS. Preventing throwing injuries. *J Orthop Sports Phys Ther* 1998; 27:187-188.
5. Oberlander MA, Chisar MA, Campbell B. Epidemiology of shoulder injuries in throwing and overhead athletes. *Sports Med Arthrosc Rev* 2000; 8:115-123.
6. Lyman S, Fleisig G, Waterbor J, et al. Longitudinal study of elbow and shoulder pain in youth baseball pitchers. *Med Sci Sports Exerc* 2001; 33:1803-1810.
7. Fleisig G, Barrentine S, Zheng N, et al. Kinematic and kinetic comparison of baseball pitching among various levels of development. *J Biomech* 1999; 32:1371-1375.
8. Andrews JR, Fleisig G. Preventing throwing injuries. *J Orthop Sports Phys Ther* 1998; 27:187-188.
9. Yen KL, Metzl JD. Sports-specific concerns in the young athlete: baseball. *Pediatr Emerg Care* 2000; 16:215-220.
10. Whiteley R. Baseball throwing mechanics as they relate to pathology and performance – a review. *J Sports Sci Med* 2007; 6: 1-20.
11. Escamilla RF, Barrentine SW, Fleisig GS, et al. Pitching biomechanics as a pitcher approaches muscular fatigue during a simulated baseball game. *Am J Sports Med* 2007; 35:23-33.
12. Zheng N, Fleisig GS, Barrentine SW, et al. Biomechanics of pitching. In: George Hung (editor). *Biomedical Engineering Principles in Sports*. Kluwer Academic/Plenum Publishers; 2004: Chapter 9.
13. Albright JA, Jokl P, Shaw R, et al. Clinical study of baseball pitchers: correlation of injury to the throwing arm with method of delivery. *Am J Sports Med* 1978; 6:15-21.
14. Buettner CM, Leaver-Dunn D. Prevention and treatment of elbow injuries in adolescent pitchers. *Athl Ther Today* 2000; 5:19-24.
15. Congeri JA. Treating- and preventing – little league elbow. *Phys Sportsmed* 1994; 22:54-64.
16. Ciccantelli P. Avoiding elbow pain: tips for young pitchers. *Phys Sportsmed* 1994; 22:65-66.
17. Fleisig GS, Andrews JR, Dillman C, et al. Kinetics of baseball pitching with implications about injury mechanism. *Am J Sports Med* 1995; 23:233-239.
18. Olsen SJ II, Fleisig GS, Dun S, et al. Risk factors for shoulder and elbow injuries in adolescent baseball pitchers. *Am J Sports Med* 2006; 34: 905-912.
19. Dun S, Loftice J, Fleisig GS, et al. A biomechanical comparison of youth baseball pitches: is the curveball potentially harmful? *Am J Sports Med* 2007 (in press).
20. USA Baseball Medical & Safety Advisory Committee Position

Statement on Youth Baseball Injuries Updated: May 2004. <http://mlb.mlb.com/usa_baseball/article.jsp?story=medsafety11> (accessed 21 December, 2007).

21. USA Baseball Medical & Safety Advisory Guidelines: May 2006. <<http://www.asmi.org/asmiweb/usabaseball.htm>> (accessed 21 December, 2007).
22. Moore Youth Baseball Association: Pitching Safety. <http://www.mooreyouthbaseball.com/pitcher_safety.htm> (accessed 21 December, 2007).
23. Limpisvasti O, ElAttrache NS, Jobe FW. Understanding shoulder and elbow injuries in baseball. *J Am Acad Orthop Surg* 2007; 15: 139-147.

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CME QUESTIONS

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Choose the answer that is most correct for each question.

1. True/False:
Elbow and shoulder pain are normal parts of pitcher development.
2. True/False:
Proper pitching mechanics are important for success and injury prevention at any age.
3. True/False:
Pitch counts, days of rest after pitching, and having an offseason away from baseball are all important for youth pitchers to reduce risk of subsequent injury in adolescence and teenage years.
4. According to the study of Olsen, Fleisig, Dun, et al, (2006) the risk factor with the strongest correlation for adolescent pitcher injury and surgery was:
 - a. Age the pitcher started throwing curveballs.
 - b. Improper pitching mechanics.
 - c. Regularly pitching despite arm fatigue.
 - d. Poor strength training.