

# Arm Issues in Young Throwers: Why are They Increasing?

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## INTRODUCTION

It has been more than 150 years since the “father of baseball” Alexander Cartwright diagrammed the first diamond and developed the rules for America’s national pastime. Over the past few decades, several other spring sports, including lacrosse, track and field, and boys’ volleyball have increased in popularity and participation has increased in these sports.<sup>1</sup> Despite this growth and athletes playing particular sports on a year-round basis, baseball’s popularity has never been higher.

Epidemiologic studies report that over 2.6 million boys between the ages of 8 and 14 participate in youth baseball organizations and countless more are involved in nonorganized baseball play.<sup>1</sup> While the benefits of participation are many, there is recent recognition of a growing number of injuries during baseball participation.<sup>1</sup> In many instances these injuries are obvious and recognizable. They have been well-documented and discussed in newspapers and magazines across the nation as well as in scientific journals. In addition to rotator cuff strains and ulnar collateral ligament sprains, there are many less recognized injuries. Recognized or not, arm injuries can potentially lead to short-term as well as long-term problems.<sup>2,3</sup> Recognizing both the obvious and less obvious injuries and injury patterns is important and ultimately will be necessary if a reduction in these injuries is to be achieved.

Sensationalization of upper extremity injuries, as described in the lay press and in books such as *The Arm* by Jeff Passan in 2016, have heightened awareness. Despite a better understanding of the arm injuries that baseball

players suffer, the incidence of these injuries is increasing. The increase in participation certainly results in an absolute increase in the number of injuries; however, several studies have documented an increase in their prevalence as well.<sup>4-8</sup> Baseball participation, like participation in other sports, carries with it an inherent risk of injury which must be accepted by each player. Recognizing the causes of the increasing incidence of injuries may assist in prevention and/or reduction of the number of injuries.

## ARM INJURIES

Arm injuries in baseball players are unfortunately common. Large epidemiologic studies and reviews document that arm injury rates are at least 50% each season.<sup>7-9</sup> These injuries result in a range of time loss, from missing a single game or practice, to sitting out the rest of the season, sometimes with permanent functional changes. Some of the more common injuries are listed in Table 1. Certainly, other injuries exist and there are countless minor injuries – abrasions, contusions, minor strains – that occur and are not reported, since they do not commonly result in missed games or practices.

Several clinical studies have reviewed baseball injuries specifically. One large national study of youth baseball players found several factors that were associated with pitching-related injuries. The most significant was when young pitchers pitched when they were tired or had arm pain – these factors increased players’ odds of sustaining an injury by as much as seven-fold.<sup>10</sup> Additionally, that same study showed lesser but statistically-significant increased odds of having an arm injury when pitchers

**Table 1. Common Arm Injuries in Baseball Players**

<i>Shoulder</i>	<i>Elbow</i>	<i>Wrist/Hand</i>
Internal impingement	Ulnar collateral ligament sprain	Triangular fibrocartilage complex (TFCC) tears
Superior labral tears (SLAP)	Medial epicondylitis	Wrist flexor strains
Shoulder instability	Ulnar neuritis	Hamate fractures
Rotator cuff strains	Valgus extension overload	
Bennett’s lesions	Olecranon stress fractures	
Proximal humeral epiphysiolysis (Little Leaguer’s Shoulder)	Medial epicondyle avulsions	

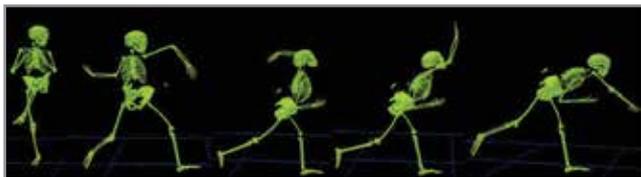
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pitched on consecutive days, pitched on more than one team consecutively, or pitched in multiple games in a given day. A recent systematic review of these injuries found that playing for multiple teams, pitch velocity, and arm fatigue were clear risk factors for shoulder and elbow injuries.<sup>11</sup> Despite recommendations designed to limit overuse arm injuries, another study found that pitchers threw competitively more than eight months of the year (13%), pitched in leagues without pitch counts (45%), pitched on consecutive days (44%), pitched in multiple games in a day (19%), and pitched for multiple teams simultaneously (30%).<sup>12</sup>

## ETIOLOGY OF ARM INJURIES: MECHANICAL

The high incidence and increasing prevalence of upper extremity injuries has led to extensive research and scrutiny as to their etiology. While some of the injuries are a result of a single throw or pitch, most are due to the repetitive nature of throwing. The act of throwing is a vigorous, whole-body act that involves the transfer of strength and power from the legs through the kinetic chain to ultimately delivering a throw or pitch with velocity and accuracy (Figure 1). While lower extremity and core injuries can and do occur, these muscles are larger and typically less susceptible to repetitive injuries in baseball players, as opposed to athletes who participate in lower extremity dominant sports such as soccer and lacrosse, who suffer overuse injuries in their legs due the repetitive nature of their respective sports.

Figure 1. The Pitching Cycle



At the root of arm injuries is the need for the power of the legs to funnel through the core, the thorax, into the shoulder girdle, and down the arm. In order to throw well, this transfer of energy needs to be efficient and reproducible. It is not surprising that the combination of these factors – large force traveling down the arm and repetition of motion – lead to injuries.

Some authors have looked beyond the repetitive nature of throwing for other causes of the increasing arm injury rate. For years, coaches have suggested that pitchers should not attempt to throw curve balls or sliders until they were older, more mature, and more experienced. A physician for the Atlanta Braves several years ago summed this up when he said, “Pitchers should not throw a curveball before they shave.” Epidemiologic studies have suggested that pitchers who throw curve balls at a young age are at increased risk for arm injuries. However, in re-

search studies that included both young and older pitchers, it was noted that the force to the shoulder and elbow when throwing a curveball is lower than when throwing a fastball due the difference in speed.<sup>13,14</sup> The difference between the information gained in motion analysis labs and long-held beliefs of pitching coaches can be confusing, and is an area of active research. One such study suggests that the whole pitching cycle, and not just the peak torque produced, should be analyzed, as was done previously in laboratory studies.<sup>15</sup> This issue, however, needs more research.

Other aspects of the pitching motion are being studied in an effort to identify movements that may increase the risk of injury. This includes everything from initiation of the motion, to striding, to rotating and bending the spine, in addition to the position or arm slot for the arm itself.<sup>16-18</sup> While changes and/or abnormalities in a pitcher’s motion (and presumably position players as well) may increase the risk of an injury, no single mechanical problem can explain all arm injuries or why the increase in injuries is occurring.

Other aspects of training and practicing, including mound height and long toss programs, have also been theorized to create issues for young pitchers. Unfortunately, research to date has yet to determine their full effect. Research comparing throwing from flat-ground vs off-the-mound determined that there were no kinetic differences in throwing from a mound while there were some kinematic differences.<sup>19</sup> Earlier studies, however, noted that there was a difference with higher forces being seen at the shoulder and elbow when throwing off-the-mound.<sup>20</sup> Studies have also looked at stress while performing long toss programs. One study, comparing a long toss program to pitching, found that the biomechanics of a long toss were similar to pitching when done at standard distances. However, when maximum throwing distances were attempted, a large difference in biomechanics was noted.<sup>21</sup>

## ETIOLOGY OF ARM INJURIES: OVERUSE

There has been a dramatic increase in young athletes’ involvement in independent baseball and travel programs, giving them the chance to play baseball several more months per year.<sup>1</sup> This has led to an increase in risk exposure for these young athletes. Authors demonstrated a significant increase in injuries, especially of the shoulder and elbow of throwing arms. In some reports, injuries to the throwing arm have occurred in as many as one half of the athletes, with pitchers more commonly affected than any other position players.<sup>7-9</sup> In a high percentage of these arm injuries, most athletes cannot remember a single event or even a day that resulted in the injury. Instead, most of the injuries build gradually or have a prodrome before participation is actually interrupted.

While overuse injuries in baseball are considered by some as the *sine qua non* of overuse injuries, they occur in other sports as well. The recognition of these injuries is closely associated with the issue of Early Sports Specialization (ESS) and research into this issue has become a focal point of many international and national organizations, as well as most professional organizations. While it is beyond the scope of this manuscript, it is important to understand the definition of ESS and understand the increased risk associated with it. ESS is defined as:

- Participation in intense training in organized sports greater than eight months per year
  - Essentially year-round
- Participation in one sport to the exclusion of participation in other sports
  - This leads to limited free play overall
- Involvement in sports as per the above in young, pre-pubertal children in seventh grade or roughly age 12 or below<sup>22</sup>

The increased risk of ESS and overuse leading to arm injuries in baseball players is well-known. Several authors have found injury rates two, three, even four times as high in athletes who play baseball exclusively.<sup>10</sup> Recently, Confino et al determined that Major League Baseball (MLB) pitchers who played multiple sports in high school pitched more innings and had fewer injuries than their counterparts who only played baseball.<sup>23</sup> Even knowing this, the allure of glory, college scholarships, and dreams of professional stardom seem to have players, parents, and coaches disregarding medical advice.

The understanding that the volume of pitches thrown in a game or a season causes an increase in injury rates has been known for some time. Early studies demonstrated that adolescent pitchers who threw more than 75 pitches in a game or 600 in a season significantly raised the odds of an elbow or shoulder injury.<sup>8</sup> A subsequent study from the same group demonstrated a 35% increase in elbow pain and a 52% increase in shoulder pain when pitch counts were between 76 and 99 pitches per day vs less than 75.<sup>7</sup> Further documentation of this risk was reported when a survey compared the pitching histories of 95 adolescent pitchers who had surgery on their shoulder or elbow and 45 pitchers who had not had surgery. The surgical group had pitched more months of the year, games per year, and innings per year.<sup>24</sup> The slow progressive nature of these injuries, however, makes it difficult to be sure what the cause is and further longitudinal studies are needed.

## PREVENTION

Injury prevention steps have been taken in many areas of baseball with significant benefit. Requiring the use of helmets both for batters and runners on the base paths is

one such step. The mandatory use of earflaps in younger individuals has significantly lessened the severity of injuries to the head. In some leagues, the use of face masks has also been introduced to help reduce injuries to the face. As another successful step in reducing injuries, break-away bases and double bases at first base have reduced the incidence of ankle and lower leg pain from direct contact injuries with plate bases and players while on the base path.

These steps have made a difference in the incidence of injuries; however, injuries to the throwing arm remain first and foremost in the discussion of baseball injuries. Additionally, as mentioned, arm injuries not only remain high but seem to be increasing in prevalence. Many of the 23 youth baseball organizations in the US have implemented steps to help reduce arm injuries. In the last decade, two specific steps have been taken to reduce injuries and to address overuse injuries. Many organizations, including Little League Baseball, have determined the proper number of live pitches to be thrown in a given game, week, and season. These numbers have been established for each age group in conjunction with USA Baseball and the Major League Baseball Health Advisory Group. After these pitch counts were established, it was realized that it would be important to establish days of rest for individuals who pitch as well. Little League Baseball and other organizations have established these numbers as seen in Tables 2 – 4. Pitchers are allowed to remain in the game, in another position, once they reach the pitch count limits. While previous rules allowed these ‘retired’ pitchers to play any other position, a recent report on the incidence of injuries in catchers has caused this to be revised. ‘Retired’ pitchers are no longer allowed to move behind the plate in many leagues.<sup>1</sup>

Several youth organizations have also established recommendations defining when it is safe for an individual to throw a certain type of pitch. Most organizations recommend that younger pitchers throw a fastball and a change-up before attempting to throw any other type of pitch. Most pitching coaches will teach these two pitches; the only difference between the two is the grip on the ball. Some organizations have also established a minimum age when it is appropriate to throw a curveball and then a slider or a cutter.

Limitations and recommendations for the number and types of pitches are fraught with concerns and there are significant gaps in or misinterpretation of scientific evidence. Several authors have demonstrated that playing baseball for eight months or more of the year, and correspondingly, throwing more balls or pitches during the year, leads to significant increases in injury rates.<sup>7</sup> While these findings are concerning, broad-based epidemiologic studies are lacking. Further, it has been well-established that the forces about the shoulder and elbow when throw-

**Table 2. Pitch Count Limits**

<i>Pitcher age</i>	<i>Pitches per day</i>
17 – 18	105
13 – 16	95
11 – 12	85
9 – 10	75
7 – 8	50

**Table 3. Required Rest Periods – Pitchers Age 14 and Under**

<i>Pitches thrown in a day</i>	<i>Calendar days of rest</i>
> 66	4
51 – 65	3
35 – 50	2
21 – 35	1
1 – 20	0

**Table 4. Required Rest Periods – Pitchers Age 15 – 18**

<i>Pitches thrown in a day</i>	<i>Calendar days of rest</i>
> 76	4
61 – 75	3
46 – 60	2
31 – 45	1
1 – 30	0

ing the curveball are actually less than those when a pitcher throws a fastball.<sup>13,14</sup> It has also been shown that the forces across both the shoulder and elbow while throwing other pitches, such as the slider and cutter, are similar to those when throwing a curveball, and again, are less than when the same individuals throw a fastball.<sup>25</sup> This scientific evidence points to the need to limit the number of throws or pitches more than trying to recommend when to throw specific pitches.<sup>26</sup> Additional evidence from this study showed a significant difference in injury rates with individuals who served as the catcher for their teams. In that study, Luke reported that when pitchers are relieved, the worst possible position for them to play during that game, and perhaps even during that week, is to assume catching duties.<sup>26</sup>

New initiatives have been developed to reduce injuries through intervention programs. In one study, teams were block randomized into an intervention team and a comparative control group. Significant reduction of injuries was noted with a simple warm-up and stretching/strengthening program.<sup>27,28</sup>

Further understanding of the mechanisms of injury, as well as risky behaviors, need to be more clearly defined and understood. The Major League Baseball Health Advisory Group and the American Orthopedic Society

for Sports Medicine (AOSSM) have each undertaken different roles to implement interventions against these risky behaviors. Evidence that arises from injury surveillance studies currently in place may help to improve the health and safety of all baseball players.

Injuries are a natural consequence of sports participation and athletes and their parents must understand the risks of the sports they play. As a better understanding of these injuries develops, and prevention measures are better understood, off-season and in-season training programs can be instituted to lessen the risks of playing our national pastime.

## RECOMMENDATIONS

The etiology of arm injuries is multi-factorial. As we increase our knowledge and understanding of these injuries, we can work to reduce their occurrence in young pitchers. At the very least, we should work to stop the increasing rate of injuries. Currently, however, some recommendations are clear. First, encouraging participation in baseball is appropriate. At the same time, early emphasis should be placed on developing athletic skills in general, and avoiding sport specialization until at least high school. Once in high school, athletes who specialize in baseball should be encouraged to take blocks of time off from throwing during the year. These blocks should be at least two months in duration, and pitchers should not throw for a total of more than eight months each year.

In a more granular view, young pitchers should learn to throw a single type of pitch well before moving on. Whether that should be a breaking pitch or not remains to be fully understood. Young pitchers also should have pitch limits per game, as listed in Table 2. As a simple rule-of-thumb, pitchers should be limited to pitching no more than six times their age in live pitches per day.

Beyond these well-researched recommendations, common sense should prevail. Pitching when tired or in pain is not appropriate and has been shown to dramatically increase injury rates. Fatigue often occurs when a pitcher pitches on back-to-back days or pitches for more than one team simultaneously.

## CONCLUSIONS

Arm injuries in young pitchers continue to be a common and serious issue. While interventions have been identified and instituted, the incidence and prevalence of these injuries is increasing. There is still much to understand about these injuries if we are going to reduce their frequency. Further investigations into safer, less risky pitches and pitching motions need to be performed. At the same time, more clinical studies need to be performed to refine recommendations further.

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