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Pitch-Count and Its Effects on Shoulder Injuries: How to Keep a Pitcher Healthy

Alexander Malek
Touro College

Pitch-count and its Effects on Shoulder Injuries. How to keep a Pitcher Healthy

Alexander Malek
Alexander will graduate in June 2015 with an Honors Biology B.S. degree.

Abstract
Baseball is currently the fourth most popular sport in high schools across the country. However, pitchers are at a high risk to develop career ending injuries. Overuse can result in SLAP tears as well as torn rotator cuff muscles that can end a dream of pitching professionally. Major League Baseball has teamed up with leading sports medicine researchers to determine safe pitch-count guidelines for pitchers of all ages. Articles were found using Touro's e-Journal database as well as Pubmed.gov to find pertinent research on this topic. Studies on ball velocity and scapular kinematics were done on three different levels of pitching. Data showed that over time fatigue sets in and pitching mechanisms change. It is important for pitchers to realize this and to act in a safe manner.

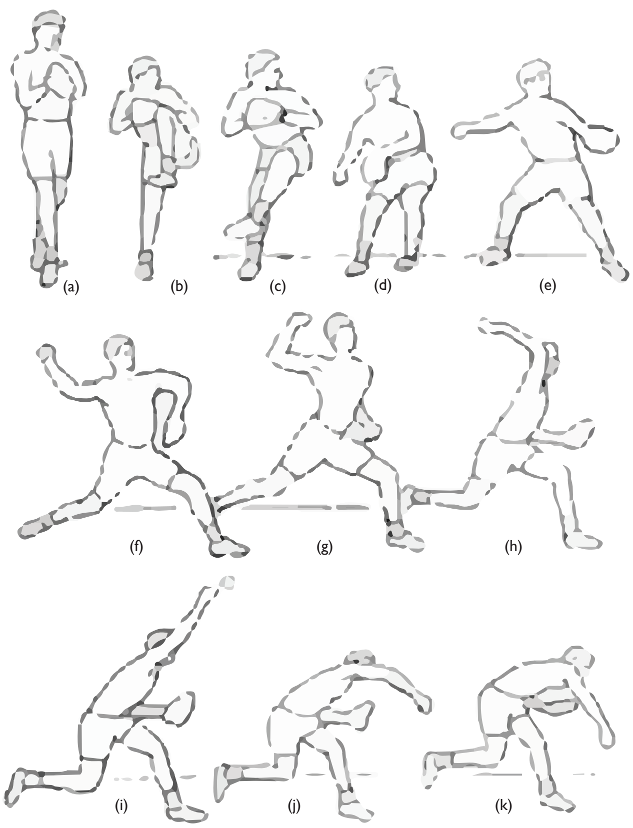
Introduction
Baseball, America's Pastime, is a sport enjoyed by men and women of all ages. The look of joy on a young child's face when receiving his first baseball glove is testament to the love of the game. Who doesn't remember going to their first baseball game? The glamour of the game as well as the part time relaxation of lazing around in the field allows for baseball and softball to be among the most popular sports for adolescents in the United States. A survey from the National Federation of High School Athletes (NFHS handbook) found in the 2013-2014 academic year, that a total of 15,789 schools listed baseball as a sport of choice for men (behind basketball and track), with 541,054 students participating (behind football as well). Fast pitch softball for females was listed as the fourth most popular sport as 15,225 schools list it as a sport (behind basketball, track, and volleyball), with 364,297 students participating (behind soccer as well). However, contrary to popular belief, as well as studies classifying baseball as a safe sport, baseball and softball are not without their fair share of injuries. Although not as prevalent or life threatening as football injuries can be, the results can be season ending, or at times, even career ending. A study done by Conte et al. (2001) on Major League pitchers has shown that 57% of pitchers suffer from a shoulder injury during a season. The study also showed a growth in injury occurrences over an 11 year period from 1989 to 1999. Estimates of injury rates for youth (ages 9-14) are a 5% risk of serious arm injury (shoulder or elbow) within 10 years (Littleleague.org).

Pitch-count Recommendations
As a result of such injury rates there has been an increasing emphasis on the pitch count during a game, as well as cumulative pitch count throughout the season. Pitch count is more strongly enforced in younger populations due to concern over how the repetitive stress that occurs with pitching alters both structural as well as functional mechanics of the young shoulder complex. Arm pain is common in youth pitchers with studies showing that risk of pain increases after 75-80 pitches per game (Lyman et al 2002). This has led to recommendations by little-league baseball for the following daily pitch maximums: ages 7-8, 50; 9-10, 75; 11-12, 85; 13-16, 95; and 17-18, 105

Methods
Journal articles were found by searching the terms "pitcher fatigue causes", "pitch-count", and "fatigue related injuries". Articles were accessed using the Touro Library databases of EBSCO, ProQuest, and Sage Premier Collection. As the topic is a sports medicine related issue, the index of The American Journal of Sports Medicine was utilized as well. Search terms were later refined to specify shoulder injuries and pitching biomechanics. A final method of research was an interview with a biomechanical shoulder researcher at the Hospital for Special Surgery (HSS).

Pitching Biomechanics
Biomechanical studies have determined that the arm is not the

Figure 1



Sequence of Motion in Pitching (Dillman et al 1993) only body part involved in pitching. A pitch can be split into 6 separate sections: wind-up, stride, arm-cocking, arm acceleration, arm deceleration, and the follow through (Dillman et al 1993), with the upper and lower limbs working in tandem for a proper pitch.

For purposes of this paper the focus will be on the shoulder, but details from other locations are needed in moderation. During the windup stage the pitcher takes a step backward with the front foot, or stride foot. As the pitcher begins, he rotates 90° and slowly lifts, elevates, and flexes the stride leg. The stride stage follows with the other leg slightly flexing, and the stride leg moving toward the catcher. This phase is most important to a safe pitch, as a key element is to control proper trunk location to contribute to a pitch. If the trunk is not as back as possible it would affect the pitch velocity. Additionally, the landing spot of the stride leg contributes to hip rotation which will interfere with the contribution of the trunk to the pitch. As the hips start to rotate, the arm is flexed at the elbow, and the shoulder undergoes maximum external rotation (arm-cocking stage). The humerus then internally rotates along the glenoid as the arm accelerates toward the plate. During the release of a pitch the scapula rotation goes from a maximum of 178° to 105° in approximately 0.029 seconds. It is important to note that a decrease in lower extremity force will often result in either a decrease in momentum or an increase in upper extremity force leading to injury.

To date there have been three studies that compared ball velocity and shoulder kinematics over the duration of a game. Murray et al (2001) studied major league pitchers, Escamilla et al (2007) collegiate, and a recent yet to be published study from HSS, studied high school pitchers. Each study has advantages over the other, with specific revelations into pitch-count related injuries.

Major League Pitchers

Murray et al (2001) was the first attempt to compare pitch velocity and pitcher kinematics over a period of time. They studied 7 pitchers (mean age 26) during spring training. 5 pitchers pitched for 5 innings with 2 pitching for 7. Cameras were placed in three different locations of the stadium to capture different angles of the pitcher. A computer program was used to manually digitize 20 different landmarks to compare over time. The program compared a fastball from the first inning as well as one from the last inning pitched.

They observed significant changes in the maximum external rotation angle of the shoulder as well as a decrease in ball velocity. A decrease of an average of 9° was noted with a 5 mph drop in velocity. Although fatigue is the probable cause for these discrepancies, the possibility of protective measures taken by the pitchers cannot be ruled out.

Collegiate Level Pitchers

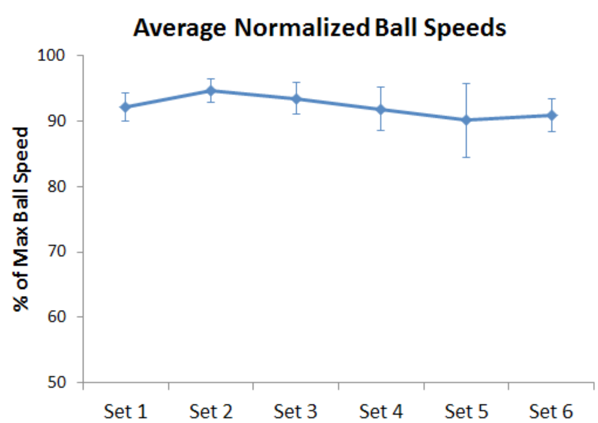
Escamilla et al (2007) chose a slightly different approach to study fatigue. They studied 10 Division I collegiate baseball pitchers with a mean age of 20. Each pitcher threw 15 pitches per "inning" with a rest period in between to simulate an actual baseball game. Five pitchers pitched the entire 9 innings (135 pitches), 2 pitchers pitched 8 innings (120 pitches), and 3 pitchers pitched 7 innings (105 pitches). Along the lines of a simulated game, the catcher called for a variety of pitches-not just fastballs. At the end of each inning pitchers were asked to scale their level of fatigue. Kinematic data were recorded using reflective markers on the pitcher to be studied using motion analysis software (more accurate than video markers used by Murray et. al). (2001)).

Although pitch velocity decreased from the first inning to the last, the only significant kinematic difference was trunk position, as the trunk was more vertical at the end than the beginning. This led Escamilla et al. to conclude that there cannot be a specific amount of pitches that determine fatigue and therefore injury. They hypothesized that in real game scenarios there are more than 15 pitches during some innings, as well as an increased level of motivation that may lead to harder throws.

High School Pitchers

A recent study from HSS (unpublished data) focused on young adults (average age was 15) during a simulated game. Participants were initially tested for range of motion in three different positions: 45° internal rotation, 0°, and 45° external rotation. After the average peak torque was determined the pitching sequences began. Once warmed up, the pitchers threw 90 fastballs in 6 sets (1 set = 15 pitches) with five-minute breaks between sets to simulate a game length situation. After the completion of the innings, participants were retested for range of motion. Kinematic data was recorded using the same method as Escamilla et al but with one major addition. They used a specialized scapula marker for more exact scapula tracking.

Figure 2



Average normalized pitching speeds across sets (unpublished data).

Although each pitcher threw with different velocities, normalized data showed that the second set of pitches were thrown the fastest, with the fifth and sixth being the slowest (Figure 2).

Isometric strength tests demonstrated decreased internal (19%-26%) and external strength (13% to 16%) for neutral and 45° internal rotation testing positions. No significant differences in strength were detected when participants were tested in 45° of external rotation.

Kinematic measurements at five pitching events (foot contact, maximum external rotation, release, and maximum internal rotation) revealed significant changes in scapulothoracic measures at maximum internal rotation. There was a 3.8° decrease in scapula backward tilt in set 6 compared to both sets 1 and 2 and scapula elevation increased by 3.6° in set 6 when compared to set 1. Abnormalities in scapula kinematics with increased scapula elevation are very common for symptomatic shoulders with possible rotator cuff tears.

This study shows that even before a pitcher feels fatigued, there is a drop in strength and velocity. Although no one complained about feeling fatigued when questioned, there were clear indications of muscular fatigue amongst the athletes, which was reflected in the reduction of the arm rotational strength and the decrease in ball speed between sets 2 and 6.

Discussion

There are only a few studies that have examined baseball during an extended number of pitches to investigate how fatigue affects upper extremity kinematics. Escamilla et. al. (2007) defined fatigue as the point at which the athletes could no longer continue pitching due to a subjective perception of muscular fatigue. This resulted in a variable number of pitches for each athlete that ranged from 105 to 135 pitches (7 to 9 innings). Although the subjects in that study didn't report fatigue, the rotational isometric strength post pitching in the HSS study clearly showed that the subjects experienced muscular fatigue during the simulated game of 90 pitches. The difference may be attributed to the higher age and level of competition of collegiate participants as studies have demonstrated that there are great differences in pitching kinematics between different levels of competition (high school, college, major league) (Fleisig 2009). An advantage in Escamilla's study over previous research was the introduction of an artificial game, allowing researchers to more accurately measure shoulder kinematics. However, this also opens a possibility of lack of effort on behalf of the pitchers leading to inaccurate data.

The advantage for Escamilla is a disadvantage for Murray et. al (2001). Since Murray was analyzing major league pitchers in real game scenarios, (albeit spring training) the actual motion capture can be inaccurate. However, a major clinical advantage was the conclusion of minimal kinematic variability as changes in external rotation can be attributed to protective measures. This shows that there is hope for young pitchers. Proper strength and conditioning, as well as being coached in proper mechanics can minimize injury risk to pitchers.

The study from HSS was advantageous in not letting pitchers wait until they felt fatigued, or let them complete a simulated game. Their research shows how fatigue affects strength and velocity before the pitcher realizes it. Add the fact that the study was done in a meaningless simulated game, and one can see the probable effect during a game. However, a major disadvantage was the type of pitch allowed. They only allowed fastballs which does not accurately portray real-life scenarios.

Muscular fatigue was also reflected in the ball speed results, as all three studies revealed a decrease in ball velocity from start to finish. This is to be expected as when one overworks any muscle there tends to be fatigue. However, the main implications are not just the ball velocity. Lyman et al (2001) surveyed a little league over the course of a season. Careful pitch counts were collected and players were interviewed at the end of each game, as well as the end of the season regarding pitch type and injuries. The results of the study led Lyman et al to recommend a maximum of 75 pitches per game as mentioned above. Interestingly enough, they also found that the more a person pitched the lower the risk of injury. This is due to lack of experience when it comes to pitchers, or possibly lack of conditioning. However, more than 600 pitches a season led to elbow pain as well, so that should be avoided.

Fleisig et al. (2011) added to this study by linking pitch type and amount to injury frequency. The American Sports Medicine Institute concluded that the players who pitched more than 100 innings in at least 1 calendar year had about 3.5 times as much chance of serious injury as those who pitched less. They also recommended not starting to throw curve-balls before the age of 13, to take a break of 2-3 months annually, and not to pitch on consecutive days (American Institute of Sports Medicine, 2013). However, subsequent reports have found that a large percentage of youth pitchers do not follow these guidelines (Yang et al. 2014).

Specific Injuries

During the release of the ball the shoulder goes from 178° to 105° in approximately 0.029 seconds. This quick motion can cause the greater tuberosity to come near the acromion. Unfortunately, the biceps tendon or supraspinatus (rotator cuff) can get caught in between. Impingement pain is easily treated with rest and physical therapy (Hawkins 1980).

The sudden interior rotation of the humerus also leads to biceps tendinitis, or a frayed long head of the biceps tendon. Although this injury alone can be treated surgically, it is also treated with rest and therapy. However, a frayed biceps is the start of a cascade of injuries. If the biceps gets frayed or torn the shoulder loses some stability. When the shoulder loses some stability it applies stress on the labrum. This leads to tears in the superior part of the labrum an injury called a superior labrum anterior and posterior, or SLAP, tear. Instability can also lead to torn rotator cuff muscles, specifically the supraspinatus. Both SLAP tears and torn rotator cuff muscles require surgery to fix.

Conclusion

Literature has shown a correlation between high pitch-counts and shoulder injuries. Although pitchers may think they are not fatigued, this has been shown to be false. Younger pitchers, who are not yet developed, both physically and in pitching mechanics, are at a higher risk for injury. This has led the American Sports Medicine Institute together with Major League Baseball to institute guidelines for young pitchers.

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References

American Institute of Sports Medicine. Position statement for youth baseball pitchers. Available at: http://www.asmi.org/research.php?page=research&section=positionStatement. Published 2012. Updated April 2013. Accessed January 5, 2015.

Conte S, Requa RK, Garrick JG. Disability days in major league baseball. Am J Sports Med. 2001; 29(4):431-6.

Dillman CJ, Fleisig GS, Andrews JR. Biomechanics of pitching with emphasis upon shoulder kinematics. J Orthop Sports Phys Ther. 1993; 18(2):402-8.

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(1):23-33.

Fleisig G, Chu Y, Weber A, Andrews J. Variability in baseball pitching biomechanics among various levels of competition. Sports Biomech. 2009; 8(1):10-21.

Fleisig GS, Andrews JR, Cutter GR, et al. Risk of serious injury for young baseball pitchers: a 10-year prospective study. Am J Sports Med. 2011; 39(2):253-7.

Hawkins RJ, Kennedy JC. Impingement syndrome in athletes. Am J Sports Med. 1980;8(3):151-8.

Lyman S, Fleisig GS, Waterbor JW, et al. Longitudinal study of elbow and shoulder pain in youth baseball pitchers. Med Sci Sports Exerc. 2001; 33(11):1803-10.

Lyman S, Fleisig GS, Andrews JR, Osinski ED. 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(4):463-468.

Murray TA, Cook TD, Werner SL, Schlegel TF, Hawkins RJ. The effects of extended play on professional baseball pitchers. Am J Sports Med. 2001; 29(2):137-42.

National Federation of State High School Associations. 2013–2014 High School Athletics Participation Survey. Available at: http://www.nfhs.org/ParticipationStatics/PDF/2013-14 NFHS Handbook_pgs52-70.pdf Accessed December 6, 2014

Pitching Regulation Changes. Little League Web site. Available at: http://www.littleleague.org/Assets/forms_pubs/media/PitchingRegulationChanges_BB_11-13-09.pdf Accessed December 6, 2015

Yang J, Mann BJ, Guettler JH, et al. Risk-Prone Pitching Activities and Injuries in Youth Baseball: Findings from a National Sample. Am J Sports Med. 2014; 42(6):1456-1463.