Use of Pitch Counts by

Varsity High School Coaches in the Midwest

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Despite advances in diagnostic abilities, early treatment intervention, sport specific strength training including prehabilitation, and an increased ability in identifying players at risk, shoulder and elbow injuries continue to plague baseball pitchers of all ages. The American Sports Institute, during two 5 year consecutive reporting periods between 1994-1999 and 2000-2004 reported a 4 fold increase in elbow surgeries in collegiate pitchers and a 6 fold increase in high school pitchers (Fleisig et al., 2006). The first prospective longitudinal study performed on youth baseball pitchers over two consecutive spring seasons found risk factors for both shoulder and elbow pain (Lyman, 2001). Lyman et al. (2001) identified elbow pain increased with age, increased weight, weight training, pitching with arm fatigue, decreased satisfaction with one’s pitching, and number of pitches thrown per season. Shoulder pain risk factors included several of the same factors including decreased satisfaction with one’s pitching, pitching arm fatigue, number of pitches thrown per season as well as number of pitches thrown per game and were confirmed by a subsequent study (Lyman et al., 2001). More recent studies have looked at pitch type (Lyman, Fleisig, Andrews, & Osinski, 2002; Fleisig et al., 2006), pitch velocity (Bushnell, Anz, Noonan, Torry, & Hawkin, 2010; Olsen, Fleisig, Dun, Loftice, & Andrews, 2006), biomechanics (Davis et al., 2009) and effects of fatigue on muscular structure and mechanics (Mair, Seaber, Glisson, & Garrett, 1996; Escamilla et al., 2007) in youth, adolescent, and collegiate baseball pitchers as risk factors for shoulder and elbow injuries.

The pitching motion is divided into five phases: wind-up phase, stride phase, arm cocking phase, arm acceleration phase, and the deceleration phase (Escamilla & Andrews, 2009).
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Understanding muscle activity, kinetics, and kinematics during pitching is essential in understanding possible mechanisms of injury, identifying biomechanical errors and developing sport specific prehabilitation and strength programs to help reduce injury. Multiple studies have looked at the pitching biomechanics, the strength of shoulder musculature of pitchers at different levels of development, as well as competition levels in an effort to ascertain specific risk factors identifiable to these particular groups.

It is during the arm cocking, arm acceleration, and deceleration phases that greatest forces and torques are placed on the throwing arm (Ivey, Calhoun, Rusche, & Bierschenk, 1985). Huang et al. (2005) assessed the internal and external rotator strength and endurance of baseball pitchers between the ages of 10 to 23. Although external rotation/internal rotation ratios for all age groups were similar, endurance measurements were significantly different among the two groups (Huang et al., 2005). The young adult and adult group demonstrated an increased ratio of ER/IR after pitching performance indicating their internal rotators were more prone to fatigue. The pre-pubescent and adolescent group, conversely, showed a decrease in their ER/IR ratio revealing a strength loss in their external rotators (Huang et al., 2005) possibly leading to a loss of anterior stability of the joint (Ticker, Fealy, & Fu, 1995). The significance of these findings may indicate that pitchers who have not reached muscular maturity may be at greater risk for overuse shoulder injuries. Programs aimed at endurance training of the external rotators in this age group may be of some benefit. Along those same findings, Trakis et al. (2008) documented greater strength of the internal rotators of the dominant side as compared to the non-dominant side in adolescent pitchers with throwing related shoulder and/or elbow pain. Weakness of the middle trapezius and supraspinatus was also documented.
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in these same pitchers when compared to pitchers without any prior arm or shoulder pain (Trakis et al., 2008). These findings suggest significant muscle imbalances between the anterior and posterior musculature compromising the integrity of the posterior shoulder resulting in the inability to withstand the energy generated by the internal rotators. Byram et al. (2009) reported an association between preseason weakness in external rotators and supraspinatus and in-season injury requiring surgical intervention in professional baseball pitchers. Lauder, Stanek, and Meister (2007) identified another possible predisposing factor in shoulder injury in the decreased scapular upward rotation unique to pitchers. These changes in scapular rhythm function could be a consequence of joint laxity and may result in reduced function of the kinetic chain and greater risk of developing glenohumeral instability and impingement syndrome (Lauder et al., 2007).

Kinetics and kinematics have been extensively studied in baseball pitchers in multiple age groups and levels of competition. Fleisig, Yungchien, Weber, and Andrews (2009) reported the greatest variations in kinematics occurred among the youngest pitchers showing the greatest inconsistency during wind-up and stride phase with front foot placement and knee flexion. Davis et al. (2009) provided evidence that youth and adolescent pitchers with proper pitching mechanics produced less humeral internal rotation torque, lower elbow valgus load, and better transfer of energy during pitching motion. Arm slot position prior to ball release appears to have the most influence on elbow valgus torque. Aguinaldo and Chambers (2009) identified 6 biomechanical variables associated with elbow valgus torque during continuous pitching motion. Three of these variables which had the greatest correlation to elbow torque were late trunk rotation, reduced shoulder external rotation, and increased elbow flexion (Aguinaldo &
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Chambers, 2009). Increased elbow flexion is a significant finding and appears to contradict current pitching instruction.

Pitch counts, days rest, and months off have gained popularity as a preventative measure against injury. Fatigue is believed to contribute to muscle strains and biomechanic breakdowns that lead to increase joint loads resulting in acute and overuse injuries. Mair, Seaber, Glisson, and Garrett (1996) reported the muscle’s ability to absorb energy is reduced anywhere from 62-92% when fatigued and concluded that muscles are most vulnerable to injury at high force loads during eccentric contraction.

Fatigue of the shoulder musculature is expected during pitching performances and could have implications in shoulder injuries. When Mullaney, McHugh, Donofrio, and Nicholas (2005) looked at muscle fatigue during pitching they identified muscles that performed internal rotation, adduction and flexion as those muscles most susceptible to fatigue with the internal rotators demonstrating the greatest changes in strength. Inconsistent fatigue patterns within the shoulder complex along with resulting change in force load may produce some insight in mechanism of injury within the shoulder. In 2001, Matsuo et al. (2001) found as a pitcher decreased their forward trunk lean and pitched in a more upright position, the velocity of the ball dropped. In a 2007 study, although Escamilla et al. failed to show a change in kinetics during a fatiguing pitching performance, they were also able to identify a change in forward truck lean that attributed to a decrease in ball velocity. These findings may help coaches to identify pitchers that are nearing fatigue or fatigued during game situations. Pitching despite arm fatigue was categorized as a risk factor by Olsen II et al. (2006). This study did not show
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cause and effect, only a correlation between fatigue and injury resulting in an increased injury risk of nearly 36%.

When looking at adolescents between the ages of 9 and 14, Lyman, Fleisig, Andrews, and Osinski (2002) found three variables played a role in shoulder and elbow pain: pitch types, pitch counts, and pitching selection. Throwing curve balls and sliders were identified as significant risk factor for developing elbow and shoulder pain in pitchers within this age group. These pitches place high force loads on both the shoulder and elbow similar to the fastball (Escamilla, 1994). A more recent study in 2008 demonstrated shoulder and elbow loads were greatest during the fastball and the curveball did not produce any more of a potential for injury than the fastball (Dun, Loftice, Feisig, Fingsley, & Andrews, 2008)). A study of collegiate pitchers, although showing significant differences in kinematics, also did not demonstrate significant differences in kinetics between the fastball and the curveball (Fleisig et al., 2006). However, the complaint of elbow and shoulder pain within the adolescent groups throwing curveballs is concerning and may be attributable to a cumulative effect along with multiple factors including inadequate mastery of the pitching mechanics, immature musculature and open growth plates, and high pitch counts.

Elbow and shoulder injuries can vary depending on the skeletal maturity of the pitcher. Ulnar collateral ligament tears are the most common and well known of the elbow injuries. However, the spectrum of baseball related elbow injuries include ulnar neuritis, flexor-pronator tendinitis/strain, stress and avulsion fractures as well as osteophytes of the olecranon, apophysitis, loose bodies and osteochondritis dissecans of the capitellum (Cain, Dugas, Wolf, &
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Andrews, 2003). Injuries to the rotator cuff musculature from either force overload or impingement syndrome including tendinitis, tendinopathy and tears, labrum tears known as SLAP lesions, and degeneration of the labrum are the most frequently diagnosed shoulder disorders in baseball pitchers (Limpisvasti, ElAttrache, & Jobe, 2007; Ouellette et al., 2008; Olsen, Fleisig, Dun, Loftice, & Andrews, 2006). Adolescent pitchers present another range of injuries within the shoulder complex at the proximal humeral growth plate often mimicking rotator cuff pathology. Carson and Gasser (1998) reported asymmetric widening of the proximal humeral physis in the dominant arm on radiographs in twenty-three pitchers with a mean age of fourteen years old.

High prevalence of overuse shoulder and elbow injuries in baseball pitchers continues to have significant effect at all levels of baseball. Recommendations based on published studies continue to be made in an effort to reduce the injury rates, especially injuries resulting in surgery and loss of pitching ability. Olsen et al. (2006) in a 2006 study made recommendations for adolescent baseball pitchers (14-20 year olds) that included avoiding pitching with fatigue and arm pain, and pitching too much which was defined as 80 pitches per game, 8 months of consecutive pitching, and 2500 pitches in a competition per year. Suggestions were also made to scrutinize starting pitchers, pitchers with velocities higher than 85mph, taller and heavier pitchers, pitchers that pitch a high volume of warm up pitches, pitchers that routinely use anti-inflammatories and ice as a preventative measure against injury, and pitchers that participate in show cases (Olsen et al., 2006).
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The purpose of this study is to identify the current use of pitch count practices used by area high school coaches in Southeast Missouri. We hypothesize that high school coaches are currently using pitch counts during pitching performances in an effort to prevent fatigue, to determine availability for upcoming games, and in an effort to reduce injury resulting in days of lost productivity.

Methods

Participants

Participants in this study consisted of 31 varsity high school coaches. Participants were recruited through Missouri High School Athletic Association within a seventy-five mile radius of Poplar Bluff and the Illinois High School Athletic Association Districts Five and Seven with public email addresses. They had a mean coaching experience of 7.6 years. Twenty eight coached at public schools with the remaining three employed at private institutions. School sizes from 1A through 4A schools were represented. The participants were given the option to take part in the survey anonymously.

Materials

A nine question survey with a five question optional quiz was utilized through Survey Monkey and emailed to 111 coaches. These questions focused on demographics of the high school coaches, number of pitchers utilized during a single spring season, age, types of pitches, velocities thrown, use of pitch counts, days rest between pitching performances, shoulder and elbow injuries including ratings of severity, and source of knowledge for usage of pitch counts.
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The optional quiz incorporated five common risk factors and recommendations for baseball pitchers as specified by USA Baseball Medical and Safety Advisory Commission.

Participants were asked to fill out the survey and submit it via email. A week was given to answer the survey. The researchers closed the survey and collected the results. The participants were given the opportunity to provide their name and email address if they were interested in obtaining results of the research.

Results

Thirty-one coaches participated in the survey which was a twenty-eight percent response rate. Of the 31 coaches, 58% had 0-6 years of experience, while the 42% remaining coaches have 8 or more years of coaching experience. In addition, of the responding schools, 71% were 1A and 2A schools, while 29% were 3A and 4A schools. Respondents represented 90% public and 10% private institutions. While the private schools only participated in spring season, 14% of the public schools participated in fall and spring baseball seasons. Of the thirty-one coaches, 50% of the participating coaches finished in the top third of their conference, while 17% finished in the lower third. While the coaches reported the fastball and change-up were utilized by every team, 96.8% of teams utilized the curveball, 54.8% threw a slider, only 16.1% threw a knuckle ball and 9.7% listed split finger under other choices of pitches in the team’s repertoire. Within the survey, every coach reported utilizing a pitch count method; 90% of the coaches always used pitch counts, while 10% sometimes utilized pitch counts. One hundred fifty-eight pitchers were identified in the survey as part of the 2010 spring season. The mean age for the pitchers was 17 years old. Sixty-seven percent of the pitchers had a maximum pitch
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count of 60-100 pitches; however, only 2.5% were throwing over 100 pitches per performance. Sixty-one percent of pitchers had 3-4 rest days between pitching performances; while less than 27% of the 158 pitchers received 2 or less days rest. However, only 2% of those pitchers receiving 2 or less days rest pitched more than 80 pitches in a single performance. Injury rates recorded included 15 pitchers experience shoulder injuries, 15 pitchers experienced elbow injuries, while 1 pitcher experienced both a shoulder and elbow injury. The severities of the injuries were dispersed into categories of none, mild, moderate and severe injuries. While 78% experience no injuries, 14% experienced mild, 6% moderate and 1% severe injuries. 97% of the coaches reported utilizing their own experiences to make their pitch count decisions while 10% of those same coaches stated they also utilized workshops and/or published books/studies to aid in them in their pitch count selection.

The optional quiz was completed by eighteen coaches with the other 12 coaches giving partial answers and one coach did not response. A pass rate (80% or higher) of 22% existed among the coaches that completed the quiz.

Discussion

Axe (2001) acknowledged 15% of US collegiate athletes no longer pitch secondary to arm injury. In continued efforts to reduce injury and protect our youth and high school pitchers, pitch counts, days rest, and months off has gained status among baseball coaching and training professionals. This survey demonstrated 90% of varsity high school baseball coaches in the Midwest regularly utilize pitch counts. Several age dependent pitch count guideline suggestions exist within baseball. USA Baseball recommends 75 pitches for 13-14
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year olds per pitching outing and not to exceed 125 pitches per week, maximum of 90 pitches for 15-16 year olds, and maximum of 105 pitches for 17-18 year olds with a maximum of 2 games per week for each. As indicated by Olsen in a 2006 study, recommendations for adolescent pitchers (14-20 year olds) were to keep pitches under 80 pitches per game. This study indicated that 28% of the respondents kept their pitch counts under 80 pitches. However, with the exception of one 14 year old who pitched over one hundred pitches per game, pitch counts were utilized according to recommended guidelines.

The number one contributing factor to injuries was pitching despite arm fatigue. During the deceleration phase of the pitching motion, eccentric contraction of posterior shoulder is essential to reduce anterior subluxation of the glenohumeral joint. Mair et al. 1996 study described a vulnerability to injury during eccentric contraction when fatigue reduces the muscles ability to absorb energy. The survey results showed that 61% of the pitchers received 3-4 days rest between performances; hence placing them in the recommended guidelines. Coaches had a good concept of proper rest days between pitching performances. Only two out of thirty-one coaches incorrectly identified the days rest ratio. USA Medical and Safety Advisory Commission comprised of eighty-five baseball experts recommend a schedule no rest days for 1-20 pitches, 1 day rest for 21-40 pitches, 2 days rest for 41-60 pitches, and 3 days rest for 61+ pitches.

Pitch selection remains an area of controversy. Several studies have producing confounding results. Lyman et al. (2002) identified pitch selection as a risk factor for shoulder and elbow pain. While a 2008 study by Dun et al. demonstrated the fastball placed more stress
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on the shoulder and elbow than the curveball, Fleisig et al. (2006) failed to show significant differences in kinetics between the fastball and curveball. However, skeletal and muscular maturity remains an area of major concern in adolescent pitchers. USA Baseball gives recommendation with regards to appropriate ages to learn specific pitches. Although curveball and slider have been indicated to increase arm injury rates, the survey found that curveball remains a highly utilized pitch (96%), while the slider is thrown by approximately 55% of the teams. The survey failed to identify the specific pitches being thrown by pitchers.

Pitch velocity of 85mph and over was identified by Olsen et al. (2006) as a risk factor for elbow and shoulder injuries among adolescent pitchers. Within the survey, only 7% (11) threw 85mph or greater. None of these pitchers were identified to have sustained any injuries.

The optional quiz provided some insight to the knowledge base of the coaches. The questions on the quiz identified areas most commonly associated with injury risk factors: pitch velocity, days rest, pitch selection, and arm fatigue. On a positive note, 82% of the coaches correctly identified the risk of utilizing a curveball in adolescents, as identified by Lyman et al. (2002). However, questions regarding risk factors of fatigue, pitch counts and velocity, yielded less than 70% correct response rate. Coaches have continued to rely on their own experience when determining appropriate pitch counts, days rest, biomechanics, and pitch selection. Extensive research has been completed over the last 10-15 years in attempts to determine the reasons for increase in injury rates among pitchers. This information is not necessarily making to the coaches. Better educational resources need to be readily available for baseball coaches at all levels of competition.
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Limitations of the study included inadequate survey responses, the inability to correlate pitch selection to specific pitcher. The survey did not address pre-existing injury conditions prior to their high school career and how they may have contributed to answers within the questionnaire. The coaches were asked to recall information from memory making it more subjective. Adjustments had to be made within the survey during the first several days. Risk factors such as biomechanics and pitching outside the high school season were not addressed.

Areas of further research could include following specific pitchers in a prospective, longitudinal study over the course of a year or high school career to identify if specific pitch counts, days rest, or pitch velocity plays a role in injury. This could include Tanner maturity scale or radiologic imaging to assess physical or skeletal maturity.

Conclusion

The game of baseball has continued to grow in popularity and become a year around sport. In an attempt to improve their skills, pitchers begin throwing at a younger age, throwing to the “radar gun”, and participating in multiple leagues throughout the year. Genetic predisposition to injury, variability in mechanics, and other factors make it difficult to identify all risk factors related to shoulder and elbow injuries, however, extensive research has been conducted over the last 10 years in attempt to identify risk factors for specific age groups and competition levels. While fatigue is the number one contributable factor to pitching related injuries, pitch counts and adequate rest days between pitching appearances remains the most efficient and straightforward way to facilitate muscle recovery and prevent injury. Along with
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improving biomechanics, coaches are able to utilize pitch counts methods, days rest, and pitch selection to moderate fatigue symptoms and reduce injury rates.
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