FASTPITCH SOFTBALL PITCHING MECHANICS, INJURY PATTERNS AND ADAPTATION: IS THERE A CORRELATION TO BASEBALL? A REVIEW OF THE LITERATURE.

MIRANDA DAVIS

Abstract

Objective

This review will look at the research that has been conducted on baseball pitching mechanics and faspitch pitching mechanics and correlate the two sports.

Background

Baseball and Fastpitch softball are two of the most popular sports for American youth. There has been much more research done on baseball than on fastpitch softball. Fastpitch softball is one of the fastest growing, and most popular female sports in the United States.
Little research has been completed on the fastpitch softball pertaining to injury pattern analysis, pitch counts, fatigue patterns and biomechanical stress in comparison to baseball.

Methods

A thorough literature search was completed using PubMed. The search included articles about baseball pitching mechanics, baseball pitching injury patterns, adaptive changes in baseball pitchers, youth baseball pitching, youth softball pitching, fastpitch softball pitching, windmill pitching, fastpitch softball injury patterns. These articles were examined and correlations were drawn by the reviewer.

Discussion

The literature reviewed for fastpitch softball pitching showed that pitchers were among the highest injured positions in the sport[11,12,13]. The joint load on the shoulder during the fastpitch softball pitch is similar to the forces placed on the shoulder during a baseball pitch, suggesting that fastpitch softball pitchers are also at risk for overuse injuries[15,16].

Conclusion

The review of literature of fastpitch softball pitching and baseball pitching is indicative that more research should be done with respect to pitch counts, fatigue, joint stress, and injury patterns for fastpitch softball pitchers.

Keywords: Baseball, Softball, Overhead Throwing Athlete, Pitching

Background

Fastpitch softball is one of the fastest growing sports in the United States and worldwide, it is being played in over 124 countries worldwide. There are currently 959 NCAA faspitch softball teams, with over 17,000 collegiate athletes participating. The sport has gained a lot of momentum with the success of the U.S. national team, winning the first three Olympic gold medals for softball and winning the silver medal in 2008. With this growth, there has been an increase in injuries seen in these athletes[12,17,18].

Practicing physicians are seeing a rise in these patients; however there are no clear cut recommendations for practice, and competition habits. There also is a shortage of literature in regards to tracking pitch counts, and injury patterns. It is hypothesized that the demand placed on faspitch pitchers, due to the low number of pitchers per team contributes to an increased incidence of injury. Pitch counts in baseball are set by governing bodies, and followed by coaches, there is no set recommendation for softball pitchers. It has been established that some pitchers are throwing an overabundance of pitches in a short period of time, while others at different levels of competition are playing fewer games and throwing less pitches overall.

Fastpitch pitchers have been recorded throwing up to 2,000 pitches in a three day tournament[11.] With this being said there is a need to research and see how many pitches, or consecutive days of pitching are healthy for this cohort of athletes.

Considering the popularity and similarity between baseball and softball a review of the literature published about baseball pitching and fastpitch pitching is being executed in the hopes of finding direct correlation between the two sports, and to provide direction for future research in the

sport. The information collected will allow the medical community to better serve these athletes, and guide future research and treatment of these athletes.

In November 2006 the article titled Risk Factors for Shoulder and Elbow Injuries in Adolescent Baseball Pitchers (Samuel J. Olsen II et al.)[19] discussed the risk factors that have been clinically observed and reported significant for baseball pitching injuries. They were reported as; increased months per year pitching, games per year, innings per game, pitches per game, pitches per year and warm-up pitches before the game. More often it is noted that the starting pitcher is injured than the reliever, also pitchers that throw at a higher velocity, pitched with arm pain, and fatigue are more likely to be injured[19].

Upon completion of this study a list of recommendations for Adolescent Baseball pitchers was established as seen below.

TABLE 1[19]

Authors' Safety Recommendations for Adolescent Baseball Pitchers

1. Avoid pitching with arm fatigue.
2. Avoid pitching with arm pain.
3. Avoid pitching too much. Further research is needed on this topic, but reasonable limits are as follows:
   a. Avoid pitching more than 80 pitches per game.
   b. Avoid pitching competitively more than 8 months per year.
   c. Avoid pitching more than 2500 pitches in competition per year.
4. Monitor pitchers with the following characteristics closely for injury:
   a. Pitchers who regularly use anti-inflammatory drugs or ice to "prevent" an injury
   b. Regularly starting pitchers
   c. Pitchers who throw with velocity □85 mph
   d. Taller and heavier pitchers
   e. Pitchers who warm up excessively
   f. Pitchers who participate in showcases

There have been no such guidelines set forth for softball pitchers, and it is becoming more common to see faspitch softball pitchers seeking medical treatment for injury. It is unknown whether these injuries occur due to number of games/innings/days pitched, or if biomechanical faults, or other causative factors are the real problem.

There has been much debate of the kinetic chain playing a major role in shoulder injury in overhead throwers, as discussed in a 2006 study by Sciascia and Kibler[20]. They found that there are a multitude of factors, including but not limited to anatomical, biomechanical, and environmental concerns that can contribute to the dysfunction of the shoulder and elbow in young overhead athletes[20]. This article also discussed understanding the load absorbing processes of the body to aid coaches, clinicians and others to prevent or limit the effects of pitching on the young thrower. This study looked at baseball and tennis respectively.

Among other subjects, there has long been a debate about the curveball being a dangerous pitch for baseball pitchers. It was postulated that the difference in the throwing mechanic placed more stress on the shoulder and elbow of the thrower. There have been articles written on this including the 2006 article by Fleiseg et al. This study noted that the rising injury rate in baseball pitchers may be less related to the curveball mechanics than originally thought[6]. There are seven pitches commonly thrown in faspitch softball. They are the fastball, change-up, curveball, screwball, roll-over drop, peel drop, and riseball. The possible mechanical repercussions of these pitches is currently unknown, as there are no articles currently published about the effects of different pitch types in relationship to injury patterns in faspitch softball players.

There have also been adaptive changes noted in range of motion of baseball pitchers[10]. In 2008 an article was published by Reinhold et al. that discussed some of these changes. It has been

recorded that there is a significant decrease in shoulder internal rotation, total motion and elbow extension in the dominant shoulder after baseball pitching. There were no changes noted in the non-dominant arm[10.] Changes in ROM in fastpitch pitchers have not been studied. These changes in baseball players have been attributed to osseous adaptations as well as ligamentous changes[10]. The balance between mobility and dynamic stability is required for the shoulder in the throwing athlete[10], due to the micro trauma of throwing there is a process of selective stretching of the anterior capsule and tightening of the posterior capsule[10]. These changes can be seen in the chart on the following page:

Fig 2[10]

Comparison of the shoulders between Throwing and Nonthrowing Groups			
Variable	Throwing group mean	Nonthrowing group mean	significanc
humeral head retroversion			
dominant	40	18	p<0.001
non dominant	23	19	ns
Glenoid retroversion			
dominant	14	13	ns
non dominant	11	12	ns
External Rotation at 90 degrees of abduction			
dominant	128	113	p<0.001
non dominant	119	112	p<.01
External Rotation in scapular plane			
dominant	102	92	p<0.01
non dominant	95	88	p<0.01
Internal Rotation at 90 degrees of abduction			
dominant	62	65	ns
non dominant	71	69	ns
Total Motion			
dominant	189	179	p<0.03
non dominant	189	181	p<0.04
Anterior Laxity			
dominant	1.36	1.28	ns
non dominant	1.24	1.2	ns
Posterior Laxity			
dominant	1.92	1.84	ns
non dominant	1.8	1.76	ns
Sulcus sign			
dominant	1.08	1.12	ns
non dominant	0.96	1.08	ns

Due to the similarities in the distractive forces between the glenohumeral joints of softball and baseball pitchers[15,16,21], it is reasonable to question whether or not similar changes occur in fastpitch athletes. As of the time of this paper there have been no articles published regarding these aspects in fastpitch athletes.

There was an article published in 2009 by Escamilla and Andrews that observed the shoulder muscle recruitment patterns and biomechanics in upper extremity sports. This article discussed the baseball pitch, windmill pitch, as well as other overhead sports. This article discussed the activation of rotator cuff musculature as well as serratus anterior being similar between the baseball pitch and windmill softball pitch[10]. Comparisons can be seen in the charts below.

Fig 3[10]

Shoulder activity by muscle and phase during baseball pitching

		Phase					
Scapular	No. of subjects	wind-up"" (% MVIC)	stride^ {% MVIC)	arm cocking" * (% MVIC)	arm acceleration" (% MVIC)	arm deceleration' (% MVIC)	follow-through ○ (% MVIC)
Upper trapezius	11	18±16	64 ±53	37 ±29	69 ±31	53 ±22	14±12
Middle trapezius	11	7±5	43 ±22	51 ±24	71 ±32	35±17	15±14
Lower trapezius	13	13±12	39 ±30	38 ±29	76 ±55	78 ±33	25±15
Serratus anterior (6th rib)	11	14±13	44 ±35	69 ±32	60 ±53	51 ±30	32±18
Serratus anterior (4th rib)	10	20 ±20	40 ±22	106±56	50 ±46	34±7	41 ±24
Rhomboids	11	7±8	35 ±24	41 ±26	71 ±35	45 ±28	14±20
Levator scapuiae	11	6±5	35±14	72 ±54	76 ±28	33±16	14±13
Glenohumeral							
Anterior deitoid	16	15±12	40 ±20	28 ±30	27±19	47 ±34	21±16
Middle deltoid	14	9±8	44±19	12±17	36 ±22	59±19	16±13
Posterior deltoid	18	6±5	42 ±26	28 ±27	68 ±66	60 ±28	13±11
Supraspinatus	16	13±12	60 ±31	49 ±29	51 ±46	39 ±43	10±9
Infraspinatus	16	11±9	3g±18	74 ±34	31 ±28	37 ±20	20±16

Teres minor	12	5±6	23±15	71 ±42	54 ±50	84 ±52	25 ±21
Subscapularis (lower 3rd)	11	7±9	26 ±22	62±19	56 ±31	41 ±23	25±18
Subscapularis (upper 3rd)	11	7±8	37 ±26	99 ±55	115±82	60 ±36	16±15
Pectoralis major	14	6±6	11±13	56 ±27	54 ±24	29±18	31 ±21
Latissimus dorsi	13	12±10	33 ±33	50 ±37	88 ±53	59 ±35	24±18
Triceps brachii	13	4±6	17±17	37 ±32	89 ±40	54 ±23	22±18
Biceps brachii	18	8±9	22±14	26 ±20	20±16	44±32	16±14

a Data are given as means and standard deviations, and expressed for each muscle as a percentage of an MVIC.
b From initial movement to maximum knee lift of stride leg.
c From maximum knee lift of stride leg to when lead foot of stride leg initially contacts the ground.
d From when lead foot of stride leg initially contacts the ground to maximum shoulder external rotation.
e From maximum shoulder external rotation to ball release. -
f From ball release to maximum shoulder internal rotation. From maximum shoulder Internal rotation to maximum shoulder horizontal adduction. "'
MVIC = maximum voluntary isometric contraction.

Fig 4[10]

activity by muscle and phase during the windmill softball pitch"

Muscles	No. of subjects	Phase wind-up (% MVIC)	6-3 o'clock position (% MVIC)	3-12 o'clock position (% MVIC)	12-9 o'clock Position (% MVIC)	10 o'clock to ball release (% MVIC)	follow-through (% MVIC)
Anterior deltoid	10	25±11	38 ±29	17±23	22 ±24	43 ±38	28±21
Supraspinatus	10	34±17	78 ±36	43 ±32	22±19	37 ±27	19±12
Infraspinatus	10	24±13	93 ±52	92 ±38	35 ±22	29±17	30±15
Posterior deltoid	10	10±5	37 ±27	102±42	52 ±25	62 ±29	34 ±29
Teres minor	10	8±7	24 ±25	87 ±21	57±21	41 ±23	44±11
Pectoralis major	10	18±11	17±12	24±18	63 ±23	76 ±24	33 ±20
Subscapularis	10	17±4	34±23	41 ±33	81±52	75 ±36	26 ±22
Serratus anterior	10	23±9	38±19	19±9	45 ±39	61±19	40±14

a Data are given as means and standard deviations, and expressed for each muscle as a percentage of an MVIC.
MVIC = maximum voluntary isometric contraction.

Methods

The researcher used the PubMed database and searched under the following terms "baseball pitching," "baseball injuries," softball pitching," "softball injuries," "baseball and softball pitching mechanics." Due to the low number of published studies on softball pitching mechanics, and injury patterns all softball items discovered were used in this article. The baseball articles were thinned by finding the most relevant and recent articles. Articles that were disproved by more recent articles were not used for this paper.

Results

Upon reviewing the literature it was determined that there were several more articles related to baseball pitching than fastpitch softball pitching. With the recent rise in popularity this is not surprising. The softball articles included articles about ground reaction forces transferred during a softball pitch[14], elite softball pitching mechanics[17], youth softball pitching biomechanics[22], and shoulder recruitment patterns in upper extremity athletes including softball and baseball pitching[10,23].

The baseball literature was much more in depth with articles ranging from the differences in biomechanics for different pitches[24], to shoulder and elbow stresses in youth baseball pitchers[2,4,7,19], also included in the literature were articles about the adaptive changes that occur in professional baseball pitchers[10]. Pictures below depict range of motion analysis in professional baseball pitchers to assess for glenohumeral internal rotation deficit which is a very common finding in overhead throwing athletes[10]. Pic 1 and 2[10]

There were articles that tied the relationship of pitch counts and training patterns to injury rates[2] and the difference in pitching biomechanics in different levels of competition[9,25,26]. In several articles the term "overhead athlete" lumped together not only softball and baseball pitchers but also American football players, tennis and volleyball athletes.

There are several more articles that use a standard for baseball pitching mechanics[1,2,7,15,27], and one that sets standards for youth softball pitching[13]. They are seen in the following two charts.

Fig 5

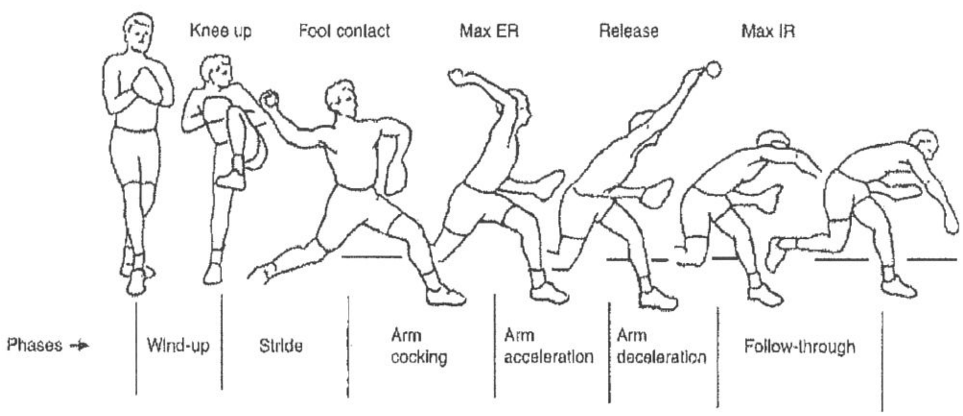
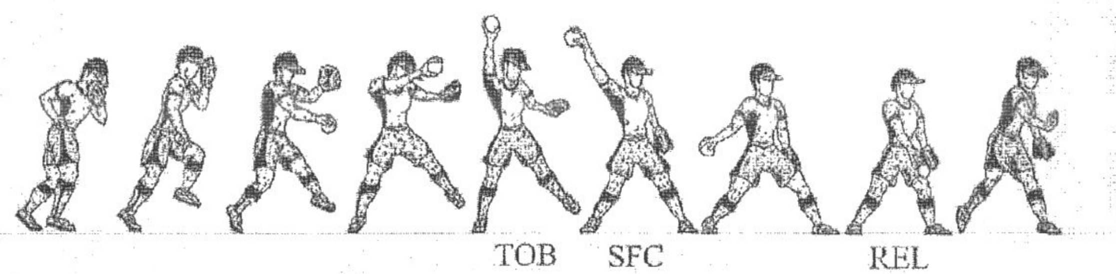


Fig. 1. Pitching phases and key events (adapted from Fleisig et al.,[12] with permission). ER = external rotation; IR = internal rotation; max = maximum.

Fig 6



There is an article written by ldubljes et al[28] that references the biceps activity in comparison to overhead throwing. They found that the biceps load was greater due to sustained eccentric contraction in the fastpitch pitch compared to the baseball pitch. In an article by Andrews et al[10] it was noted that the load on the shoulder complex in softball was similar to the baseball pitch as noted previously in fig[10].

It has been established that shoulder injuries among softball and baseball players are common, and vary by position played on the field[19]. Pitchers in both sports have a higher prevalence of shoulder and elbow injuries than other position players[12].

Discussion

The research that has been completed on fastpitch softball pitching is far less in number than on baseball pitching. There could be different reasons for this from a later rise in popularity, to funding, to the interest level being lower due to the professional aspects of fastptich being far less than that of baseball.

With the recent rise in popularity of the sport of fastpitch softball it would be beneficial to have more research regarding the injury patterns associated with fastpitch pitching, pitch count analysis, the biomechanical forces generated on the joints from different pitch types, training patterns as related to injury rates and the development of youth fastpitch softball pitchers. It would also be beneficial to know if there are any adaptations in range of motion as there are in the shoulders of many baseball pitchers. Learning what could clinically indicate a risk of injury for a fastpitch athlete would also be beneficial in order to help screen these athletes as they are training and help to lower their risk of injury. A longitudinal study that follows pitchers as they

accumulate years of practice and playing would help to set developmental standards for these athletes.

Knowing that the incidence of injury is higher for faspitch pitchers than other position players, more research in order to set standard recommendations in pitch counts, practice and competition habits would be beneficial. This information could help guide coaches, athletic trainers, parents and physicians on better strategies to treat, train and help prevent injury in this cohort of athletes.

The limitations of this study are there was only one reviewer. The reviewer is a faspitch softball instructor and chiropractic student. There could be a bias in the reviewer's interpretation of the literature.

Funding and Conflict of Interest

No funding was received for this literature review.

References

1. Fleisig GS, Andrews JR, Dillman CJ, Escamilla RF. Kinetics of baseball pitching with implications about injury mechanisms. *Am J SportsMed.* 1995;23:233-239.

2. 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;30:463-468.

3. Lyman S, Fleisig GS, Waterbor JW, et al. Longitudinal study of elbow and shoulder pain in youth baseball pitchers. *Med Sci Sports Exerc.* 2001;33:1803-1810.

4. Torg JS, Pollack H, Sweterlitsch P. The effect of competitive pitching on the shoulders and elbows of preadolescent baseball players. *Pediatrics.* 1972;49:267-272.

5. Werner SL, Fleisig GS, Dillman CJ, et al. Biomechanics of the elbow during baseball pitching. *J Orthop Sports Phys Ther.* 1993;17:274-278.

6. Escamilla R, Fleisig G, Barrentine S, Zheng N, Andrews J. Kinematic comparisons of throwing different types of baseball pitches. *J Appl Biomech.* 1998;14:1-23.

7. Dillman CJ, Fleisig GS, Andrews JR. Biomechanics of pitching with emphasis upon shoulder kinematics. *J Orthop Sports Phys Ther.* 1993;18:402-408.

8. Fleisig GS, Kingsley DS, Loftice JW, et al. Kinetic comparison among the fastball, curveball, change-up, and slider in collegiate baseball pitchers. *Am J Sports Med.* 2006;34:423-430.

9. Sabick MB, Kim YK, Torry MR, Keirns MA, Hawkins RJ. Biomechanics of the shoulder in youth baseball pitchers: implications for the development of proximal humeral epiphysiolysis and humeral retrotorsion. *Am J SportsMed.* 2005;33:1716-1722.

10. Crockett HC, Gross LB, Wilk KE, et al. Osseous adaptation and range of motion at the glenohumeral joint in professional baseball pitchers. Am J Sports Med. 2002;30(1):20–26.

11. Hill JL, Humphries B, Weidner T, Newton RU. Female collegiate windmill pitchers: influences to injury incidence. *C.* 2004;18(3):426-431.

12. Loosli AR, Requa RK, Garrick JG, Hanley E. Injuries to pitchers in women's collegiate fast-pitch softball. *Am J Sports Med.* 1992;20(1):35-37.

13. Werner SL, Jones DG, Guido JA Jr, Brunet ME. Kinematics and kinetics of elite windmill softball pitching. *Am J Sports Med.* 2006;34(4):597-603.

14. John A. Guido, JR, Sherry L Werner, and Keith Meister. Lower-Extremetiy Ground Forces in Youth Windmill Softball Pitchers. Journal of Strength and Conditioning Research.2009; 23(6)/1873–1876

15. Rafael F. Escamila and James R. Andrews. Shoulder Muscle Recruitment Patterns and Related Biomechanics during Upper Extremity Sports. Am J Sports Med. 2009:39 (7)/569-588

16. Werner SL, Gill TJ, Murray TA, Cook TD, Hawkins RJ. Relationships between throwing mechanics and shoulder distraction in professional baseball pitchers. *Am J Sports Med.* 2001;29:354-358.

17. Werner SL, Jones DG, Guido JA Jr, Brunet ME. Kinematics and kinetics of elite windmill softball pitching. *Am J Sports Med.* 2006;34(4):597-603.

18. Flynn M. Softball slides into the 21st century: growth in popularity of softball in schools. *Parks Recreation.* 1995;30(4):36.

19. Barrentine SW, Fleisig GS, Whiteside JA, Escamilla RF, Andrews JR. Biomechanics of windmill softball pitching with implications about injury mechanisms at the shoulder and elbow. *J Orthop Sports Phys Ther.* 1998;28:405-415.

19. Olsen SJ, Fleisig GS, Dun S, Loftice J, Andrews JR. Risk factors for shoulder and elbow injuries in adolescent baseball pitchers. *Am JSports Med.* 2006;34:905-912.

20. Aaron Sciascia, MS, ATC and W. Ben Kibler, MD. The Pediatric Overhead Athlete: What is the Real Problem? Clin J Sport Med. 2006:16 (6) 471-477

21. Maffet MW, Jobe FW, Pink MM, et al. Shoulder muscle firing patterns during the windmill softbaii pitch. Am J Sports Med 1997; 25 (3): 369-74

22. Werner SL, Guido JA, McNeice RP, Richardson JL, Delude NA, Stewart GW. Biomechanics of youth windmill softball pitching. *Am JSports Med.* 2005;33(4):552-560.

23. Maffet MW, Jobe FW, Pink MM, Brault J, Mathiyakom W. Shoulder muscle firing patterns during the windmill softball pitch. *Am J SportsMed.* 1997;25(3):369-374.

24. Glenn S. Fleisig,* PhD, David S. Kingsley, Jeremy W. Loftice, Kenneth P. Dinnen, MS, Rajiv Ranganathan, Shouchen Dun, MS, Rafael F. Escamilla, PhD, and JamesAndrews, MD. Kinetic Comparison Among the Fastball,Curveball, Change-up, and Slider in Collegiate Baseball Pitchers. Am J Sports Med 2006: 24 (3) 423-430

25. Dun S, Fleisig GS, Loftice J, Kingsley D, Andrews JR. The relationship between age and baseball pitching kinematics in professional baseball pitchers. *J Biomech.* 2007;40:265-270.

26. Fleisig GS, Barrentine SW, Zheng N, Escamilla RF, Andrews JR. Kinematic and kinetic comparison of baseball pitching among various levels of development. *J Biomech.* 1999;32:1371-1375.

27. 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 (I): 23-33

28. Idubijes L. Rojas, Matthew T. Provencher, Sanjeev Bhatia, Kharma C. Foucher, Bernard R. Bach, Jr, Anthony A. Biceps Activity During Windmill Softball Pitching : Injury Implications and Comparison With Overhand Throwing. *Am J Sports Med* 2009 37: 558-564