

## [ Orthopaedic Surgery ]

# Prospective Player-Reported Injuries in Female Youth Fast-Pitch Softball Players

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**Background:** There is a scarcity of literature evaluating injuries in youth fast-pitch softball players.

**Purpose:** To perform a descriptive analysis of player-reported injuries in youth fast-pitch softball position players and pitchers during a single select-level season.

**Study Design:** Prospective observation cohort study.

**Level of Evidence:** Level 3.

**Methods:** Ninety-eight athletes (48 pitchers, 50 position players) were followed for a single select fast-pitch softball season. Study participants completed web-based surveys every 3 weeks reporting injuries related to participation in fast-pitch softball. Injury was defined as pain causing cessation of participation in the current game or practice that prevents the player's return to that session or any pain that causes cessation of a player's customary participation on the day after the day of onset.

**Results:** The median age of the study participants was 14 years (range, 9-18 years). There were 49 reported injuries in 98 athletes. The average age was 13 years for those not injured and 14 years for those who were injured ( $P < 0.02$ ). There were 31 injuries that were not related to pitching: 19 occurred in position players and 12 occurred in pitchers; 70% of these injuries were to the lower extremity. The proportion of injuries not related to pitching was significantly greater than the proportion of injuries related to pitching ( $P < 0.02$ ). Eighteen injuries among the 48 pitchers (38%) were directly attributed to pitching. Among the 18 pitching injuries, 11 (61%) involved the shoulder. The majority (78%) of injuries related to pitching occurred in the first 6 weeks of the season.

**Conclusion:** There was a high incidence of injury in this prospective cohort of youth select-level fast-pitch softball players. Better off-season and preseason conditioning may be a key factor for reducing pitching injuries.

**Clinical Relevance:** Recognition of injury patterns in fast-pitch softball players is critical to developing strategies to keep these athletes competing safely.

**Keywords:** injury; softball; pitching; female athlete

More than 2 million female athletes play fast-pitch softball, making it one of the most popular female sports in the United States.<sup>2,10,20</sup> Despite this popularity, there is a paucity of literature describing injury incidence and patterns associated with fast-pitch softball participation in youth athletes, particularly at the select level. Injury data reported from athletic trainer databases indicate that

the overall injury rate in fast-pitch softball is comparable with or exceeds that in baseball.<sup>6,12-14,17</sup>

Select-level softball differs from high school softball in that the age range for youth athletes is more variable. Differences in physical development among youth athletes may influence injury patterns compared with high school and collegiate athletes. Also, select-level softball typically includes players with

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The authors report no potential conflicts of interest in the development and publication of this article.

DOI: 10.1177/1941738115606058

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Figure 1. Flowchart outlining participant enrollment, loss to follow-up, and survey completion.

high skill level and involves rigorous practice and game schedules. The select-level softball season typically starts in April and ends in August and generally does not overlap with the middle or high school seasons. Additionally, tournament schedules are more compact and rigorous than high school and collegiate competition schedules. A weekend tournament may extend to 9 to 12 games within 3 to 4 days, requiring 18 to 36 hours of actual playing time. Pitchers are particularly vulnerable to extended playing time as teams may use only 1 pitcher for a tournament because there are no regulations on pitching exposure. While youth baseball pitchers are limited to a maximum of 210 pitches per week,<sup>8,11</sup> fast-pitch softball pitchers have no limits on pitch counts and may pitch 70 to 100 pitches for 2 to 3 games per day over a 3- to 4-day tournament. While the traditional thinking is that the windmill pitch is safer because it uses an underhand motion, recent studies have shown that the windmill pitch produces similar biomechanical stresses on the shoulder as the overhand pitch.<sup>1,4,9,15,21,22</sup> Recognition of injury incidence in pitchers is critical to developing strategies to keep these athletes competing safely.

The purpose of this study was to perform a descriptive analysis of player-reported injuries in fast-pitch softball position players and pitchers during a single select-level season to provide insight into injuries sustained in these athletes and to improve injury prevention strategies (protective equipment, training programs, competition schedules, etc). We hypothesized that pitching would account for a higher incidence of injury than fielding, base running, or hitting.

## METHODS

Institutional review board approval was obtained prior to the start of the study. Between January 2011 and March 2011 and prior to the youth select softball season, 156 female fast-pitch softball athletes between 9 and 18 years old were enrolled. Of

those enrolled, 44 athletes did not respond to any surveys during the course of the season despite numerous attempts to contact these athletes. Ten athletes quit playing softball early in the season unrelated to injury. Four athletes formally withdrew from the study after the initial survey citing that they did not want to take time to complete the forms. An additional 8 players completed surveys at the beginning of the season but elected to stop completing the surveys after the first 6 weeks (Figure 1). Attempts to obtain basic injury information regarding injuries through phone calls and email correspondence during the remainder of the season were unsuccessful.

The athletes were recruited primarily from the Washington University in St Louis orthopaedic clinics and the St Louis Baseball and Fastpitch Academy. Fast-pitch softball athletes were asked to complete a web-based survey developed by the authors using Research Education Data Capture (REDCap) software. Surveys were sent on 6 occasions (every 3 weeks) during the season starting 2 weeks after the start of the season in April 2011 through the end of the select season in August 2011. Each survey asked about their participation in fast-pitch softball since the prior survey, the type of participation (games, practice, instruction), the average number of games played per week, games pitched per week, the number of days participating in fast-pitch softball, injuries sustained playing fast-pitch softball, number of games or amount of time lost due to the injury, and treatment received for any injury related to softball. We contacted participants by phone, email, or in person if they failed to respond to the web-based survey.

We defined injury as the development of pain that caused cessation of participation in the current game or practice that prevents the player's return to that session or any pain that caused cessation of a player's customary participation on the day after the day of onset. This definition was based on a previous study evaluating injury patterns in high school sports.<sup>12,14</sup> Timing of the injury was classified as early season

(April 1 to May 21), midseason (May 22 to July 16), and late season (July 17 to August 31).

### Statistical Analysis

The sample size estimate of 156 participants was based on the potential available participants to obtain a 90% CI for injury given an expected 60% survey completion for this longitudinal survey study. We used SAS statistical software to perform descriptive statistics; the Student *t* test was used for continuous variables and chi-squared analysis for comparison of dichotomous outcomes, with a *P* value cutoff <0.05 for statistical significance. The cumulative injury incidence was calculated for all participants as the number of injuries divided by the number of participants in the study. Participants who did not respond to the surveys were censored participants. By convention of dealing with censored participants in epidemiology, they were assigned a half-person weight since they have equal chance of being injured or not injured. Then, these participants were subtracted from the total study population.<sup>19</sup> The relative risk (RR) and 95% CI of injury related to pitching compared with fielding, hitting, or base running position players were calculated; 95% CIs that did not include 1 were considered statistically significant.

## RESULTS

A total of 90 (58%) athletes completed injury surveys for the entire select softball season. An additional 8 athletes completed injury surveys only during the first 6 weeks of the season, yielding a total 98 athletes (63%) with reportable injury surveillance data. The median age of the 98 players who were followed for all or part of the select softball season was 14 years (range, 9-18 years). The mean age for uninjured players was 13 years and for injured players was 14 years (*P* < 0.02). There were 48 pitchers and 50 position players. Overall, there were 49 injuries reported in 43 athletes during the select season. The cumulative incidence of injury in all participants, including censored participants, was 40% during the select season. A summary of injuries is listed in Table 1.

Questions regarding games pitched, games played, and days of participating in fast-pitch softball were answered in approximately 50% of the surveys at the beginning and middle of the season and were answered in 30% of the surveys at the end of the season, making these data less useful for accurately assessing exposure. Although the data regarding exposure were incomplete in many participants, in those who completed this portion of the survey, there were no differences in the number of games played or days played between pitchers and position players (*P* < 0.5). Among those reporting this information, the median number of games pitched per week was 2 (range, 1-9). The median number of games played per week was 4 (range, 1-12), while the median number of days participating in fast-pitch softball per week was 5 (range, 1-7).

There were 31 injuries that were not related to pitching: 19 in position players and 12 in pitchers. The proportion of injuries not related to pitching was significantly greater than that of

injuries related to pitching (*P* < 0.02). Fielding accounted for 45% of the injuries, base running accounted for 21% of the injuries, and hitting accounted for 18% of the injuries (Table 2). In pitchers, 2 injuries were attributed to hitting, 1 to fielding, 4 to base running, and 5 were from an unknown mechanism; 70% of injuries not related to pitching were lower extremity injuries. One position player required surgery to treat a hip labral tear. The majority (75%) of injuries not related to pitching resulted in fewer than 2 weeks of time missed from softball.

There were 18 injuries in 48 pitchers (38%) directly attributed to pitching. Among the 18 pitching injuries, 11 (61%) involved the shoulder (Table 3). The majority (78%) of injuries related to pitching occurred within the first 6 weeks of the season. No pitching injuries occurred in the last 6 weeks of the season. Nine pitching injuries (50%) led to 2 or more weeks of time lost from participation in fast-pitch softball. Four pitchers had season-ending injuries, and an additional 3 pitchers lost more than 6 weeks of participation in fast-pitch softball. Only 1 pitcher had a shoulder injury that resulted in surgery. Although specific pitch counts were not collected, pitchers were asked to report their mean number of pitches thrown per game since their previous survey. The majority (40.9%) of pitchers threw between 50 and 75 pitches or between 75 and 100 pitches (36.5%) per game. Also, 85% of pitchers reported participating in pitching instruction during the season.

Pitching resulted in an RR of 2.1 (95% CI, 0.94-4.6) times higher risk of an injury lasting longer than 2 weeks than an injury not related to pitching. Injuries related to pitching were more likely than injuries not related to pitching to occur during the first 6 weeks of the season (*P* < 0.01) and to involve the upper extremity (*P* < 0.01).

## DISCUSSION

This study, the first prospectively collected player-reported assessment of injuries in select-level youth fast-pitch softball athletes, identified a high incidence of injury during a single select-level softball season. Injuries not related to pitching were more common, but the majority of these injuries resulted in less than 2 weeks of lost time. Conversely, 50% of the pitching injuries resulted in at least 2 weeks of lost time. Interestingly, injuries related to pitching were more likely to occur at the beginning of the season. Although one may expect injuries to occur later in the season because of cumulative fatigue, these data suggest that a sudden increase in physical activity related to the sport may be a more substantial risk factor for injury. While it is true that some players participate in off-season pitching or hitting instruction, these activities are typically much less intense than in-season play. Poor conditioning may not be a problem for pitchers and players at low-intensity activity. As the demands of competition increase, poor conditioning may result in risk for pain or injury.

Pitching injuries were more likely to involve the upper extremity, particularly the shoulder. Shanley et al<sup>17</sup> also showed that upper extremity injuries in softball players were 2.6 times

Table 1. Reported injuries

| Timing of Injury                               | Injury Reported            | Mechanism             | Time Missed     |
|--|----------------------------|-----------------------|-----------------|
| <i>Pitching injuries (n = 18)</i>              |                            |                       |                 |
| Early season                                   | Shoulder pain              | Pitching              | No games missed |
| Early season                                   | Shoulder pain              | Pitching              | No games missed |
| Early season                                   | Shoulder pain              | Pitching              | No games missed |
| Early season                                   | Shoulder pain              | Pitching              | 2 games         |
| Early season                                   | Shoulder pain              | Pitching              | 1 week          |
| Early season                                   | Shoulder pain              | Pitching              | Entire season   |
| Early season                                   | Shoulder pain              | Pitching              | Entire season   |
| Early season                                   | Shoulder pain              | Pitching              | Entire season   |
| Early season                                   | Ulnar stress fracture      | Pitching              | 4 months        |
| Early season                                   | Wrist ganglion cyst        | Pitching              | 6 weeks         |
| Early season                                   | Knee injury                | Pitching              | 3 games         |
| Early season                                   | Hip pain                   | Pitching              | No games missed |
| Early season                                   | Back pain                  | Pitching              | No games missed |
| Early season                                   | Lumbar stress fracture     | Pitching              | Entire season   |
| Middle season                                  | Knee injury                | Pitching              | 11 games        |
| Middle season                                  | Shoulder pain              | Pitching              | No games missed |
| Middle season                                  | Shoulder biceps tendinitis | Pitching              | 2 weeks         |
| Middle season                                  | Shoulder biceps tendinitis | Pitching              | 25 games        |
| <i>Injuries unrelated to pitching (n = 31)</i> |                            |                       |                 |
| Early season                                   | Wrist sprain               | Fielding              | No games missed |
| Early season                                   | Wrist sprain               | Fielding              | No games missed |
| Early season                                   | Hip pain                   | Fielding              | 1 game          |
| Early season                                   | Thumb sprain               | Fielding: second base | 3 games         |
| Early season                                   | Wrist sprain               | Base running          | 3 games         |
| Early season                                   | Knee injury                | Base running          | No games missed |
| Early season                                   | Back pain                  | Hitting               | No games missed |
| Early season                                   | Hip pain                   | Hitting               | 2 games         |
| Early season                                   | Ankle injury               | Hitting               | Not reported    |
| Early season                                   | Ankle injury               | Hitting               | 3 games         |
| Early season                                   | Back pain                  | Player uncertain      | Not reported    |
| Middle season                                  | Knee injury                | Fielding              | No games missed |

*(continued)*

Table 1. (continued)

| Timing of Injury | Injury Reported      | Mechanism            | Time Missed     |
|------------------|----------------------|----------------------|-----------------|
| Middle season    | Knee injury          | Fielding             | No games missed |
| Middle season    | Hip injury           | Fielding             | 6 weeks         |
| Middle season    | Back stress fracture | Fielding             | Entire season   |
| Middle season    | Shoulder dislocation | Fielding: outfield   | 6 weeks         |
| Middle season    | Ankle injury         | Base running         | No games missed |
| Middle season    | Ankle injury         | Base running         | No games missed |
| Middle season    | Ankle injury         | Base running         | 1 month         |
| Middle season    | Ankle injury         | Player uncertain     | No games missed |
| Late season      | Hip labral tear      | Fielding: outfield   | 6 months        |
| Late season      | Elbow injury         | Fielding             | No games missed |
| Late season      | Knee injury          | Fielding             | No games missed |
| Late season      | Ankle sprain         | Fielding: catcher    | 4 practices     |
| Late season      | Hamstring strain     | Fielding: first base | 2 months        |
| Late season      | Knee injury          | Fielding: catcher    | 5 games         |
| Late season      | Ankle fracture       | Base running         | 2 months        |
| Late season      | Elbow injury         | Hitting              | 3 games         |
| Late season      | Elbow injury         | Hitting              | 4 games         |
| Late season      | Back pain            | Player uncertain     | 1 game          |
| Late season      | Ankle injury         | Player uncertain     | No games missed |

more likely in pitchers compared with field position players. These clinical findings are consistent with biomechanical studies showing that the windmill pitching motion places similar stress on the shoulder as the overhand pitching motion.<sup>1,15,21,22</sup>

Although we cannot make any suggestions for pitch count limits for pitchers based on our data, these findings suggest that the windmill pitch is not as safe as is commonly assumed.

Our study data show a similar incidence of injuries in pitchers to that reported in elite college pitchers. Loosli et al<sup>7</sup> reported that 20 of 24 elite college softball pitchers reported injury during the season. Hill et al<sup>5</sup> reported that 72% of college pitchers reported injury during a single collegiate season. Of these injuries, 44% were directly related to pitching. They also showed that shoulder injuries were common among pitchers. College athlete injury data, although similar to our findings, may not be useful to model injuries in youth athletes because physical development in a 14-year-old may be substantially different than a college female athlete. Weaknesses in core and scapular strength, which are risk factors for injury in throwing

athletes, may be more pronounced in a physically immature 14-year-old athlete compared with a physically mature collegiate athlete. At least for youth pitchers, it appears that the preponderance of injury in the early portion of the season argues against cumulative fatigue as the culprit and argues for a lack of preseason preparation with a rapid increase in physical activity as the potential cause for injury. Shanley et al<sup>16</sup> showed that pitch counts did not differ between softball pitchers who were injured compared with those who were not injured. Rather, deficits in glenohumeral internal rotation predicted a higher risk of injury.<sup>18</sup> Although physical examination findings were not part of the scope of this study, future studies to evaluate preseason strength and range of motion differences and their relation to injury among pitchers may provide specific targets for conditioning to decrease early season injuries in youth select-level pitchers.

There are clear limitations of this study. First, our response rate was approximately 60%, which introduces potential nonresponder bias. Because of this, it is possible that our data

Table 2. Injuries unrelated to pitching

| Injury type         | No. |
|---------------------|-----|
| <i>Fielding</i>     |     |
| Knee                | 4   |
| Hip                 | 3   |
| Hand/Wrist          | 3   |
| Ankle               | 1   |
| Lumbar spine        | 1   |
| Elbow               | 1   |
| Hamstring           | 1   |
| Shoulder            | 1   |
| Total               | 15  |
| <i>Base running</i> |     |
| Ankle               | 4   |
| Wrist               | 1   |
| Knee                | 1   |
| Not reported        | 1   |
| Total               | 7   |
| <i>Hitting</i>      |     |
| Ankle               | 2   |
| Elbow               | 2   |
| Back                | 1   |
| Hip                 | 1   |
| Total               | 6   |
| <i>Uncertain</i>    |     |
| Back                | 2   |
| Ankle               | 2   |
| Total               | 4   |

overestimate the injury rate in these athletes. Despite this, the injury rate for pitchers in our study is similar to data seen in other studies.<sup>5,7,17</sup> Additionally, there is evidence that suggests that the nonresponse rate is a poor predictor of the magnitude of responder bias.<sup>3</sup> Second, we relied on the athletes to report the development of pain that limits their performance or participation in fast-pitch softball. There is likely some variability among players in what constitutes an injury. We do not have a physician

Table 3. Pitching injuries

| Injury type | No. |
|-------------|-----|
| Shoulder    | 11  |
| Knee        | 2   |
| Back        | 2   |
| Ulna        | 1   |
| Wrist       | 1   |
| Hip         | 1   |
| Total       | 18  |

diagnosis for the majority of the injuries. The details of the injuries are limited to body location and player position unless the participant provided additional information regarding their injury to one of the study team members. Third, despite our attempts to collect these data, we do not have a clear dose response of participation related to injury because of the incomplete data regarding games played and games pitched. Last, we did not ask pitchers to track and provide specific pitch counts because we could not assure the accuracy of these data. Rather, we asked them to provide an average number of pitches per game to give us a global estimate of pitching exposure.

## CONCLUSION

There was a high incidence of injury in this prospective cohort of youth select-level fast-pitch softball players. Pitching resulted in more upper extremity injuries, particularly to the shoulder. Nonpitching injuries were more likely to involve the lower extremity injuries. Pitching in fast-pitch softball may not be as safe as previously assumed. Rapid increase in pitching activity may be a risk factor for injury since the majority of injuries occurred during the first third of the season. Better off-season and preseason conditioning may be a key factor for reducing pitching injuries. Further research is needed to determine pitch count limits and specific risk factors for injury among pitchers.

## ACKNOWLEDGMENT

This publication was supported by the Washington University Institute of Clinical and Translational Sciences grant UL1 TR000448, sub-award TL1 TR000449, from the National Center for Advancing Translational Sciences. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

## REFERENCES

1. Barentine 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.

2. Flynn M. Softball slides into the 21st century: growth in popularity of softball in schools. *Parks Recreation*. 1995;30(4):36.
3. Groves RM, Peytcheva E. The impact of nonresponse rates on nonresponse bias: a meta-analysis. *Public Opin Q*. 2008;72:167-189.
4. Guido JA Jr, Werner SL, Meister K. Lower-extremity ground reaction forces in youth windmill softball pitchers. *J Strength Cond Res*. 2009;23:1873-1876.
5. Hill JL, Humphries B, Weidner T, Newton RU. Female collegiate windmill pitchers: influences to injury incidence. *J Strength Cond Res*. 2004;18:426-431.
6. Krajnik S, Fogarty KJ, Yard EE, Comstock RD. Shoulder injuries in US high school baseball and softball athletes, 2005-2008. *Pediatrics*. 2010;125:497-501.
7. Loosli AR, Requa RK, Garrick JG, Hanley E. Injuries to pitchers in women's collegiate fast-pitch softball. *Am J Sports Med*. 1992;20:35-37.
8. 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.
9. Maffet MW, Jobe FW, Pink MM, Brault J, Mathiyakom W. Shoulder muscle firing patterns during the windmill softball pitch. *Am J Sports Med*. 1997;25:369-374.
10. Meyers MC, Brown BR, Bloom JA. Fast pitch softball injuries. *Sports Med*. 2001;31:61-73.
11. Petty DH, Andrews JR, Fleisig GS, Cain EL. Ulnar collateral ligament reconstruction in high school baseball players: clinical results and injury risk factors. *Am J Sports Med*. 2004;32:1158-1164.
12. Powell JW, Barber-Foss KD. Injury patterns in selected high school sports: a review of the 1995-1997 seasons. *J Athl Train*. 1999;34:277-284.
13. Rauh MJ, Macera CA, Ji M, Wiksten DL. Subsequent injury patterns in girls' high school sports. *J Athl Train*. 2007;42:486-494.
14. Rechel JA, Yard EE, Comstock RD. An epidemiologic comparison of high school sports injuries sustained in practice and competition. *J Athl Train*. 2008;43:197-120.
15. Rojas IL, Provencher MT, Bhatia S, et al. Biceps activity during windmill softball pitching: injury implications and comparison with overhand throwing. *Am J Sports Med*. 2009;37:558-565.
16. Shanley E, Michener LA, Ellenbecker TS, Rauh MJ. Shoulder range of motion, pitch count, and injuries among interscholastic female softball pitchers: a descriptive study. *Int J Sports Phys Ther*. 2012;7:548-557.
17. Shanley E, Rauh MJ, Michener LA, Ellenbecker TS. Incidence of injuries in high school softball and baseball players. *J Athl Train*. 2011;46:648-654.
18. Shanley E, Rauh MJ, Michener LA, Ellenbecker TS, Garrison JC, Thigpen CA. Shoulder range of motion measures as risk factors for shoulder and elbow injuries in high school softball and baseball players. *Am J Sports Med*. 2011;39:1997-2006.
19. Szklo M, Nieto FJ. *Epidemiology—Beyond the Basics*. 3rd ed. Burlington, MA: Jones & Bartlett Learning Books; 2014.
20. US Census Bureau. The 2012 statistical abstract. 2012. <http://www.census.gov/compendia/statab/2012edition.html>. Accessed March 2013.
21. Werner SL, Guido JA, McNeice RP, Richardson JL, Delude NA, Stewart GW. Biomechanics of youth windmill softball pitching. *Am J Sports Med*. 2005;33:552-560.
22. Werner SL, Jones DG, Guido JA Jr, Brunet ME. Kinematics and kinetics of elite windmill softball pitching. *Am J Sports Med*. 2006;34:597-603.

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