

Upper Extremity Functional Status of Female Youth Softball Pitchers Using the Kerlan-Jobe Orthopaedic Clinic Questionnaire

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Background: Softball is a popular sport with a high incidence of upper extremity injuries. The Kerlan-Jobe Orthopaedic Clinic (KJOC) questionnaire is a validated performance and functional assessment tool used in overhead athletes. Upper extremity pain patterns and baseline KJOC scores have not been reported for active female youth softball pitchers.

Purpose/Hypothesis: The purpose of this study was to establish the prevalence of upper extremity pain and its effect in female youth softball pitchers over a competitive season. We hypothesized that participants who missed time due to injury in the past year would have lower KJOC scores.

Study Design: Cross-sectional study; Level of evidence, 3.

Methods: Fifty-three female softball pitchers aged 12 to 18 years were recruited from softball clinics in Vancouver, British Columbia, Canada. All participants self-identified as a pitcher on a competitive travel team. Participants were administered the KJOC questionnaire before and during the playing season. Missed time due to injury in the past year, current pain patterns, and KJOC scores were primary outcomes.

Results: The mean (\pm SD) preseason KJOC score was 87.2 ± 10.6 . In the preseason, 22.6% of pitchers reported playing with arm trouble, and 32.1% missed time due to injury in the past year. The mean KJOC score for pitchers reporting a previous injury ($n = 17$) was significantly lower compared with those without an injury ($n = 36$) (79.5 ± 13.8 vs 90.9 ± 6.2 , respectively; $P = .02$). The posterior shoulder was the most commonly reported pain location. For the cohort completing the questionnaire both before and during the playing season ($n = 35$), mean KJOC scores did not change significantly over the playing season ($P = .64$). Lower preseason KJOC scores were significantly related to the in-season injury risk ($P = .016$). Pitchers with a preseason score of less than 90 had a 3.5 (95% CI, 1.1-11.2) times greater risk of reporting an in-season injury.

Conclusion: Female youth softball pitchers have a high baseline functional status. However, 1 in 3 pitchers reported missed time due to injury in the previous year, and shoulder pain was more prevalent than elbow pain. The KJOC questionnaire can be used by coaches, researchers, and clinicians to identify youth softball pitchers at risk for injuries who may benefit from interventions.

Keywords: softball; shoulder injury; screening; youth; pitcher

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Women's softball has grown in popularity over the past 25 years, and youth participation continues to increase.^{13,14} While injury rates in games are low^{8,10} and have remained stable over time,¹⁴ overuse injuries among softball pitchers are prevalent.^{7,12} Similar to baseball, softball organizations have proposed limiting innings pitched at minor levels (age <19 years) to prevent overuse injuries. Protecting young athletes from the consequences of early specialization and burnout is an emerging priority in youth sports,⁹ but there are little data in youth softball to inform policy.

The Kerlan-Jobe Orthopaedic Clinic (KJOC) questionnaire was developed to assess overhead athletes' functional status and responsiveness to interventions (eg,

rest, treatment, surgery).¹ It is sensitive to upper extremity throwing dysfunction, and baseline KJOC scores have been established in both professional baseball^{5,6,11} and collegiate swimming.²¹ KJOC scores have not yet been determined in female youth softball. It is important to establish normative data for this population before the effect of interventions on upper extremity pain and functional status can be evaluated.

The purpose of this study was to assess the prevalence and patterns of upper extremity pain and injuries in female youth softball pitchers over a competitive season. We hypothesized that KJOC scores would be significantly lower in pitchers reporting missed time due to injury in the past year. We also hypothesized that preseason KJOC scores would be related to the in-season injury risk, allowing us to establish a KJOC cut-off score that researchers, coaches, and health care providers could use to identify athletes at risk for missing time due to injury.

METHODS

Study Design

This was a cross-sectional study of active female youth softball pitchers in Vancouver, British Columbia. Participants completed the KJOC questionnaire before the competitive playing season began (January-February 2016) and before it ended (July 2016). The KJOC questionnaire inquires about athlete demographics, injury status, and upper extremity function, and it has previously been validated in overhead athletes.¹ The 10 questions on the KJOC give a total possible score of 100, with higher scores indicating higher function. An additional question asking about pain location—front of the shoulder, top of the shoulder, back of the shoulder, lateral side of the shoulder, medial side of the elbow, lateral side of the elbow, forearm, wrist, and lower extremity—was added.

Study Participants

Softball pitchers aged 12 to 18 years were invited to participate during preseason pitching clinics in Vancouver, British Columbia. Athletes were included if they actively played on a competitive travel team and self-identified as a pitcher. Written informed consent was obtained from participants using an adolescent assent form, with ethics approval as per institutional policy. Parents were provided a copy of assent forms and investigator contact information.

Study Procedure

A letter outlining the study was sent via electronic correspondence to all registered members of the Amateur Softball Association of British Columbia. One of the investigators administered surveys and answered questions regarding the study at local pitching clinics or team practices. A letter describing the study was provided to all participants and their parents. After obtaining consent, the KJOC questionnaire was administered. It took roughly 10

minutes to complete. The investigator read all questions aloud to ensure the understanding of younger participants.

Before the end of the playing season, participants were invited to complete a follow-up KJOC questionnaire. It was identical to the KJOC questionnaire administered in the off-season. Again, one of the investigators administered the surveys at team practices or before/after games and was available to answer questions.

Statistical Analysis

Analysis was performed using deidentified data with unique study identification numbers. The proportion of participants per age category, reported injury status, and pain location were calculated. Independent-paired *t* tests and 1-way analysis of variance were used to compare demographic mean values between age and injury categories. KJOC scores were calculated according to the original description.¹ The Shapiro-Wilk test of KJOC scores showed a nonnormal distribution. The Kruskal-Wallis test was used to compare mean KJOC scores by age category (≤ 14 , ≤ 16 , and ≤ 18). The Mann-Whitney test was used to compare mean KJOC scores of independent samples by injury category and time. The association between a preseason KJOC score of less than 90 and an increased in-season injury risk was determined using chi-square tests. The a priori KJOC cut-off score was based on work by Kraeutler et al,¹¹ who showed normal KJOC scores greater than 90 in asymptomatic baseball players. The relative risk of an in-season injury was determined for participants reporting a preseason KJOC cut-off score of less than 90 versus those who reported higher scores. Significance for all statistical tests was set at $P < .05$.

RESULTS

Fifty-three participants completed preseason KJOC questionnaires. Preseason cohort characteristics are found in Table 1. The mean body mass index (BMI) was calculated for participants aged ≤ 16 and ≤ 18 years only using self-reported height and weight. There were no significant differences in age, height, and BMI between participants reporting missed time due to injury and those not having missed time in the previous year (Table 1). Participants reporting a previous injury had significantly more years pitched relative to previously uninjured participants ($P = .03$).

Table 2 shows the prevalence of missed time due to injury, treatment, and agreement with the statement “playing but with arm trouble.” Mean KJOC scores are reported by age category and for “yes” and “no” answers to each question. Of participants reporting missed time due to injury, 18.9% reported having missed time due to a shoulder injury and 5.7% an elbow injury. Six of 17 (35%) of previously injured participants had both a shoulder injury and an elbow injury. Of participants who reported receiving injury-related treatment in the past year, 28% reported rest, and 40% reported physical therapy. None reported surgery. The pain patterns are also described in Table 2. Mean KJOC scores and ranges by individual question are reported in Table 3.

TABLE 1
Participant Characteristics^a

	Total (N = 53)	Previously Injured (n = 17)	Uninjured (n = 36)	P Value
Age, y	14.5 ± 1.6	15.1 ± 1.5	14.3 ± 1.6	.11
Height, m	1.68 ± 0.8	1.71 ± 0.7	1.66 ± 0.8	.07
Body mass index, kg/m ²	21.6 ± 2.8	21.9 ± 3.5	21.4 ± 2.3	.6
Years pitched	6.1 ± 2.0	7.0 ± 2.0	5.7 ± 1.9	.03

^aValues are presented as mean ± SD.

TABLE 2
Prevalence and Pattern of Preseason Upper Extremity Pain and Prior Injuries^a

	n (%)	KJOC Score, Mean ± SD	P Value
Age category			.509
≤14	15	88.2 ± 13.0	
≤16	23	86.5 ± 10.1	
≤18	15	87.5 ± 9.3	
Missed time due to injury			.02
Yes	17 (32)	79.5 ± 13.8	
No	36 (68)	90.9 ± 6.2	
Treatment			.005
Yes	27 (51)	83.3 ± 12.3	
No	26 (49)	91.3 ± 6.6	
Playing with arm trouble			<.001
Yes	11 (20)	76.0 ± 13.0	
No	42 (80)	90.2 ± 7.7	
Pain			.002
Yes	41 (77)	85.1 ± 11.0	
No	12 (23)	94.6 ± 3.7	
Location			
Anterior shoulder	12 (23)		
Top of shoulder	18 (34)		
Lateral side of shoulder	7 (13)		
Posterior shoulder	23 (43)		
Medial elbow	15 (28)		
Lateral elbow	10 (19)		
Forearm	8 (15)		
Wrist	4 (8)		
Lower extremity	10 (19)		

^aKJOC, Kerlan-Jobe Orthopaedic Clinic.

Follow-up Questionnaires

Of the 53 participants, 35 (66%) completed follow-up questionnaires near the end of the season. The range of innings pitched in the past 7 days was 0 to 49 innings. For the cohort completing both the preseason and follow-up questionnaires, the mean age was 14.3 ± 1.7 years, the mean height was 1.69 ± 0.8 m, the mean BMI was 21.5 ± 2.9 kg/m², and the mean years pitched was 6.2 ± 2.1 years. Eleven of 35 reported an injury during the season, 14 of 35 sought treatment, and 10 of 35 were playing with arm trouble. Mean KJOC scores did not differ over time (preseason KJOC, 87.0 ± 12.5 vs in-season KJOC, 87.0 ± 14.8; *P* = .64). There was a significant relationship between reporting a preseason KJOC score of less than 90 and an in-season

injury (*P* = .016). Participants with an off-season KJOC score of less than 90 had a 3.5 (95% CI, 1.1-11.2) times greater risk of reporting in-season missed time due to injury compared with participants reporting a score higher than 90.

DISCUSSION

This is the first study describing the injury prevalence, pain patterns, and functional status of female youth softball pitchers using the KJOC questionnaire. Baseline scores have been established in active minor league baseball pitchers (mean, 92.1 ± 12.1)⁶ and active collegiate swimmers (79.0 ± 18.7).²¹ The mean KJOC score of 87.2 ± 10.6 in our study indicates a high baseline functional status of female youth softball pitchers. Consistent with previous reports, we found significantly lower KJOC scores for pitchers reporting missed time due to a previous injury, those having received treatment, and those playing with arm trouble.^{1,5,6,21} The mean preseason KJOC score that we report in female youth softball pitchers is slightly lower than what Fronek et al⁶ found in active minor league baseball pitchers during preparticipation physical examinations, which may reflect a younger heterogeneous group of athletes that has not yet self-selected a sport or position based on the injury status. Importantly, we confirmed that a KJOC cut-off score of 90 could be used to identify softball pitchers most at risk for injuries. Using 90 as a cut-off score has been previously suggested in the literature but not yet proven in a prospective cohort of pitchers.¹¹ Researchers, coaches, and clinicians can use the preseason KJOC questionnaire to identify female youth softball pitchers with a KJOC score of less than 90, who are most at risk for an in-season injury and who may benefit most from an injury prevention intervention.

Previously, Hill et al⁷ found no relationship between years pitched and overuse injuries in female collegiate softball pitchers. In contrast, we show that years pitched was significantly related to injury status in our youth cohort. At the collegiate level, there is a selection bias whereby pitchers susceptible to injuries during adolescence are unable to perform at a level that would award them a National Collegiate Athletic Association (NCAA) roster spot. Similarly, years pitched was not found to be an independent risk factor for injuries to the shoulder or elbow in a cohort of high school and collegiate baseball players in Alabama, whereas annual throwing volume was.¹⁵ We did not track throwing volume in the form of game appearances and innings pitched in our study. Typically, athletes who pursue

TABLE 3
Preseason KJOC Scores by Question^a

KJOC Functional Questionnaire	Mean ± SD	Range
1. How difficult is it for you to get loose or warm up prior to competition or practice?	8.5 ± 1.6	3-10
2. How much pain do you experience in your shoulder or elbow?	7.5 ± 2.0	2-10
3. How much weakness or fatigue do you experience in your shoulder or elbow?	8.0 ± 1.8	2-10
4. How unstable does your shoulder or elbow feel during competition?	8.9 ± 1.7	1-10
5. How much have your arm problems affected your relationship with coaches?	9.7 ± 0.7	5-10
6. How much have you had to change your throwing motion due to your arm?	8.9 ± 1.7	2-10
7. How much has your velocity and/or power suffered due to your arm?	9.0 ± 1.3	3-10
8. What limitation do you have in your endurance in competition due to your arm?	8.6 ± 1.5	3-10
9. How much has your control suffered due to your arm?	8.7 ± 1.5	3-10
10. How much does your arm affect your current level of function (ie, is your arm holding you back from your full potential)?	9.3 ± 1.2	4-10
Total	87.2 ± 10.6	50-99

^aKJOC, Kerlan-Jobe Orthopaedic Clinic.

pitching instruction outside of team practice at a young age are the primary pitcher on their team and are more likely exposed to a greater annual throwing volume compared with athletes who start pitching later in adolescence. In agreement with our findings, Jayanthi et al⁹ recently reported that youth athletes suffering from overuse injuries are more likely older and have a higher degree of specialization. A larger cross-sectional study powered to perform multivariate analysis is needed to determine which factors are significantly related to the injury risk in female youth softball pitchers (eg, age, years pitched, annual throwing volume, and degree of sport specialization) before conclusions can be made to prevent injuries in this age group.

Our results confirm that in youth softball, shoulder injuries are more prevalent than elbow injuries.¹⁸ The pattern of injury in softball is different from what is typically seen in youth baseball.¹⁶ Previous studies have shown that forces at the shoulder during the windmill pitch are high, even at the youth level.^{2,19,20} Skillington et al¹⁷ found that shoulder pain and fatigue worsened over consecutive days of pitching in a tournament. No study to date has asked about the location of shoulder pain (eg, anterior, top, lateral, posterior). A review article by a team physician for the National Pro Fastpitch suggests that in addition to anterior shoulder pain, periscapular pain is prevalent as part of the overuse injury pattern seen in female softball pitchers.¹³ Pitchers in our study also noted a high prevalence of posterior shoulder pain in addition to reporting anterior shoulder pain. Without biomechanical analysis and electromyography, it is difficult to hypothesize the pathophysiological mechanisms underpinning these findings, but softball pitchers with poor biomechanics certainly have the potential to get into extremes of horizontal abduction during their pitching motion, similar to baseball pitchers. More research into known factors explaining posterior shoulder pain in overhead-throwing athletes^{3,4} is needed in female softball pitchers.

Strengths of this study include using a validated questionnaire to establish the prevalence of missed time due to injury and associated upper extremity functional status.

We received follow-up questionnaires from a majority of participants, allowing us to make conclusions about the in-season injury risk based on preseason KJOC scores. However, our conclusions are limited to a cohort with a defined off-season, and the prevalence of injuries and upper extremity pain may be underestimated. There is some evidence that the geographic location of youth competition predicts the injury status in collegiate baseball players.²² It would be interesting to replicate this study in a warmer climate where athletes are more likely to compete year-round. Second, because of the nature of self-report surveys, our study is subject to recall bias. We did not collect data on innings pitched and assumed that self-reported active pitchers played or practiced at least a portion of the season in that position. Last, conclusions cannot be applied to adult and collegiate softball players. Further studies are needed to quantify baseline KJOC scores in collegiate, professional, and Olympic-level softball pitchers.

CONCLUSION

Among competitive female youth softball pitchers, the baseline functional status is high. Mean KJOC scores were significantly lower for pitchers reporting upper extremity pain and playing with arm trouble. One in 3 pitchers reported missed time due to injury in the previous year, and the prevalence of shoulder pain was higher than elbow pain. A preseason KJOC score of less than 90 was related to a significantly increased in-season injury risk. More research is needed to identify athlete, environmental, and biomechanical factors that predict and prevent upper extremity injuries in female youth softball players.

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