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Upper Extremity Musculoskeletal Characteristics and the Kerlan-Jobe Orthopaedic Clinic Questionnaire Score in Collegiate Baseball Athletes

Mallory S. Faherty, PhD, LAT, ATC*; Aldo Plata, MA, LAT, ATC†; Patrick Chasse, DPT, LAT, ATC, SCS‡; Robert Zarzour, MA, LAT, ATC†; Timothy C. Sell, PhD, PT*

*Michael W. Kryzyzewski Human Performance Laboratory, Department of Orthopaedic Surgery and †Department of Athletic Medicine, Duke University, Durham, NC; ‡Toronto Blue Jays Baseball Club, Dunedine, FL

Context: Upper extremity (UE) musculoskeletal injuries are common in baseball athletes due to the increased demand placed on the UE. The link between risk factors for UE musculoskeletal injuries and baseball athletes' perceived UE function and pain, as measured by the Kerlan-Jobe Orthopaedic Clinic (KJOC) questionnaire, is unclear.

Objective: To (1) describe the musculoskeletal characteristics of the UE (posture, range of motion, flexibility, and isometric strength) in a population of baseball athletes and (2) determine the predictive capability of UE musculoskeletal characteristics for the KJOC score in these athletes.

Design: Cohort study.

Setting: Athletic training room.

Patients or Other Participants: A total of 37 male National Collegiate Athletic Association Division I baseball athletes (age = 20.10 ± 1.27 years, height = 186.96 ± 7.64 cm, mass = 90.60 ± 10.69 kg).

Intervention(s): Athletes self-reported all shoulder musculoskeletal injuries and completed the KJOC questionnaire. Postural assessment consisted of forward head and shoulder posture. Flexibility tests characterized glenohumeral internal and external rotation, posterior shoulder tightness, and pectoralis minor length. Strength tests involved the lower and middle trapezius, rhomboid, glenohumeral internal and external rotation, pectoralis major, serratus anterior, supraspinatus, and upper trapezius.

Main Outcome Measure(s): All 10 KJOC questions were summed for an overall score out of 100. Questions 1 through 5 were summed for a pain score; questions 6 through 10 were summed for a function score. All data were assessed for normality. A stepwise multiple regression model was fit to determine if the predictor variables assessed could predict the KJOC score. We set the α level a priori at .05.

Results: For the KJOC total score, a 1-year history of shoulder injury accounted for 7.80% of the variance in the KJOC total score ($P = .07$). For KJOC questions 1 through 5, a history of UE injury in the year before testing and posterior shoulder tightness accounted for 14.40% of the variance in the KJOC total score ($P = .047$).

Conclusions: The link between a history of UE musculoskeletal injuries and the KJOC score highlights the need for continued focus on self-perceived pain and function after UE musculoskeletal injury.

Key Words: posture, range of motion, flexibility, isometric strength

Key Points

- A history of musculoskeletal injury in the year before the study and posterior shoulder tightness predicted a portion of the variance in the Kerlan-Jobe Orthopaedic Clinic score total for questions 1 through 5 in baseball athletes.
- Continued focus should be placed on self-perceived pain, function, and performance after upper extremity musculoskeletal injury.
- When baseball athletes return to sport participation after upper extremity injury, they should be screened for continuing pain and self-perceived performance.
- To provide the most effective treatment, injury prevention and rehabilitation programs for the upper extremity should be aimed at caring for athletes' physical and mental wellbeing.

Upper extremity (UE) musculoskeletal injuries are common in baseball athletes due to the increased demand placed on the UE during baseball participation.[1] Pain in the UE is also a substantial, persistent concern for baseball athletes and is often related to throwing, which requires dynamic movement through the torso, shoulder, elbow, wrist, and fingers.[2–4] Reports of pain associated with throwing and pitching may result from the repetitive, cumulative microtrama the glenohumeral joint sustains during the dynamic overhand throwing motion.[5,6] Repeating this motion numerous times causes fatigue in the UE and decreased self-perceived sport performance.[4,7] Maintaining UE health in baseball athletes is important for player safety and performance.

Upper extremity health can be broadly defined as the UE having no joint pain or musculoskeletal injury. It is directly

Table 1. **Demographics for Pitchers and Position Players**

Characteristic	Mean ± SD Overall (n = 30)	Pitchers (n = 16)	Position Players (n = 14)	t_{28} Value	*P* Value
Age, y	20.10 ± 1.27	20.13 ± 1.45	20.07 ± 1.07	0.113	.91
Height, cm	186.96 ± 7.64	190.21 ± 6.82	183.24 ± 6.96	2.766	.01[a]
Mass, kg	90.60 ± 10.69	92.00 ± 11.37	89.00 ± 10.03	0.761	.45

[a] Difference between pitchers and position players ($P < .05$).

linked to maintaining functional joint stability, which depends on maintaining proper UE range of motion (ROM), flexibility, and strength.[8,9] Maintaining these musculoskeletal characteristics, specifically while remaining free of pain and musculoskeletal injury, is necessary for optimal baseball performance. Suboptimal UE ROM, flexibility, and strength are known risk factors for UE pain and musculoskeletal injury.[7,10–12] Glenohumeral internal-rotation deficit (GIRD) has a negative correlation with muscle power and strength of the glenohumeral joint; baseball athletes who demonstrate GIRD have also demonstrated decreased muscle strength and quality-of-life measurements.[7,13,14] Total arc-of-motion loss has been reported to predict future injury.[15] Together, GIRD and loss of total arc of motion from side to side may be indicative of future pain, injury, lack of performance, or both.[15] A lack of strength in the glenohumeral joint can lead to increased pain in that joint.[7] Relying on the musculature for stability translates to a need for increased strength to maintain proper mechanics during the overhand throwing motion. Changes in UE ROM, strength, and flexibility contribute to alterations in throwing biomechanics.[7,13]

The link between these UE musculoskeletal characteristics, which are known risk factors for UE musculoskeletal injury, and baseball athletes' perceived UE function and pain has not been established. Establishing this relationship may allow for better discrimination among baseball athletes who do not have UE pain, are playing with UE pain, and are not playing due to UE pain. Therefore, the primary purpose of our study was to describe the musculoskeletal characteristics of the UE (posture, ROM, flexibility, and isometric strength) in a population of baseball athletes. We compared position players and pitchers and compared athletes with or without a 1-year history of UE musculoskeletal injury. The secondary purpose of our study was to determine the predictive capability of musculoskeletal characteristics of the UE—posture, ROM, flexibility, and isometric strength—for the Kerlan-Jobe Orthopaedic Clinic (KJOC) questionnaire score in baseball athletes. We hypothesized that posture, UE ROM, flexibility, and isometric strength would offer predictive capability for the KJOC score. Descriptive data regarding UE musculoskeletal characteristics, as well as comparisons between baseball athletes with or without a 1-year history of UE musculoskeletal injury, are presented to provide a reference database. The results of our study will contribute to a more comprehensive understanding of the UE musculoskeletal characteristics that are important to UE musculoskeletal health, function, and performance in baseball athletes. This 1-team analysis may provide unique insight into UE pain in baseball athletes, enabling athletic trainers (ATs) to use our results to tailor injury-prevention and rehabilitation programs that more efficiently meet the needs of these athletes.

Table 2. **Demographics for Injured and Uninjured Players**

Characteristic	Mean ± SD Injured Players (n = 5)	Uninjured Players (n = 25)	t_{28} Value	*P* Value
Age, y	21.00 ± 1.41	19.92 ± 1.19	−1.803	.08
Height, cm	191.21 ± 11.30	186.05 ± 6.63	−1.489	.15
Mass, kg	94.71 ± 10.00	89.78 ± 10.83	−0.940	.36

METHODS

Participants

For this descriptive cohort study, we recruited male baseball athletes from a National Collegiate Athletic Association Division I institution. The inclusion criteria were as follows: (1) male between the ages of 18 and 40 years, (2) currently rostered and participating as a varsity-level collegiate baseball athlete, and (3) cleared by medical personnel (certified AT or team physician) to participate in full physical activity. A total of 37 athletes were enrolled (Tables 1 and 2). All participants provided written informed consent, and the study was approved by the Duke Health Institutional Review Board.

Procedures

All testing was carried out by a certified AT (M.S.F.), who is trained and proficient in UE posture, ROM, flexibility, and isometric-strength testing. Intertester reliability for the chosen methods has been established in a small sample of recreationally active individuals.[16] All participants underwent 1 test session that occurred within 4 weeks of the start of the 2017 collegiate baseball season. The session lasted approximately 45 minutes and consisted of a UE injury history questionnaire, KJOC questionnaire, and assessments of posture, ROM, flexibility, and isometric strength.

Shoulder Injury History. During the test session, injury histories were collected from all athletes. They self-reported all shoulder-joint injuries sustained over their lifetimes. These injuries were confirmed by the certified AT responsible for their care if they were under the care of the certified AT at the time of injury; the injury information was collected as part of a preparticipation physical examination, or both.

Kerlan-Jobe Orthopaedic Clinic Questionnaire. All athletes completed the KJOC questionnaire during the test session. This questionnaire has been shown[2] to be a valid, reliable, and responsive instrument for gathering patient-reported outcome measures in baseball athletes. The questionnaire comprises 10 questions about UE health and function. Athletes were instructed to place an *x* on a 10-cm line associated with each of the 10 questions. The position of the x indicated their current level of performance or function, or both. An *x* placed closer to the right indicated a higher rating for performance, function, or both.

Postural Assessment. We assessed forward head posture and bilateral forward shoulder posture.[17–19] A lateral photograph was taken of each athlete bilaterally. Before taking the lateral photograph, we provided the athletes with standardized instructions to look straight forward with their UEs at their sides as if they were "standing in a line." Next, we placed marks on the humeral heads and the spinous process of the C7 vertebra, which are the necessary landmarks for assessing forward head and bilateral forward shoulder posture. After each photograph was uploaded to the computer, we used the ImageJ (version 1.51h; National Instititues of Health, Bethesda, MD) program to assess posture. To measure forward head posture using the angle tool, 1 line was drawn from the tragus to the spinous process of the C7 vertebra, and another line was drawn parallel to the floor from the spinous process of the C7 vertebra. To measure bilateral forward shoulder posture, 1 line was drawn from the spinous process of the C7 vertebra to the mark made on the humeral head, and another line was drawn parallel to the floor from the mark made on the humeral head. The angle formed at the intersection of the lines for both forward head posture and forward shoulder posture was measured and reported.

Upper Extremity Range of Motion and Flexibility Assessments. Upper extremity ROM and flexibility were measured using preestablished techniques[20–22] that have been shown to have good to excellent reliability.[16,20–22] The measures consisted of passive glenohumeral internal and external rotation, posterior shoulder tightness, and pectoralis minor length. All measures were collected for the dominant and nondominant UEs. The *dominant UE* was defined as the athlete's throwing arm. For each test of UE ROM and flexibility, we collected 3 measurements and averaged them for data analysis.

Passive glenohumeral internal and external rotation were used to isolate and measure the athlete's internal- and external-rotation ROM.[22] Each athlete lay supine on a treatment table with the shoulder positioned in 90° of abduction and the elbow flexed to 90°. The examiner stabilized the scapula during the assessment. Both assessments were based on the recommendations of Norkin and White.[22] All measurements were taken to the nearest 0.1°.

We used posterior shoulder tightness to assess the extensibility of the posterior shoulder capsule.[21] The athlete lay supine on a treatment table with the shoulder flexed to 90° and the elbow flexed to 90°. The examiner horizontally adducted the shoulder by bringing the extremity across the athlete's chest until a normal end-feel was reached; during the test, the examiner ensured no movement occurred in the scapula. All measurements were taken to the nearest 0.1°.

Pectoralis minor length was used to assess the flexibility of the pectoralis minor muscle. The athlete lay supine on a treatment table with his arms resting comfortably on the treatment table beside his body and his hands folded across his abdomen. The examiner palpated and subsequently marked the posterior lateral tip of the acromion. Using a double square, the examiner measured from the top of the treatment table to the mark that was made on the posterior lateral tip of the acromion. All measurements were made level, perpendicular to the treatment table, and to the nearest millimeter.

Shoulder Isometric-Strength Assessments. Isometric strength of the UE was measured using previously established protocols[23,24] that have demonstrated good to excellent reliability.[16] The middle trapezius, lower trapezius, rhomboid, glenohumeral internal and external rotation, pectoralis major (lower fibers), serratus anterior, supraspinatus, and upper trapezius were tested. A handheld dynamometer (HHD; Lafayette Instrument Co, Lafayette, IN) was used to perform all isometric-strength testing. We conducted all such trials as "make tests." During a make test, the examiner holds the HHD steady as the individual exerts maximal force. Athletes were allowed 1 practice trial at 50% of their perceived maximal effort for each testing position. A total of 3 measured trials at 100% of the athlete's perceived maximal effort were performed by the dominant and nondominant UEs. Each trial lasted 5 seconds; a 60-second rest period was given between trials to prevent fatigue. Peak force was recorded to the nearest 0.1 kg, and the average of 3 trials each for the dominant and nondominant UEs was used for data analysis.

Middle trapezius isometric strength was measured with the athlete lying prone on a treatment table, the head positioned in neutral, and the elbow of the test limb fully extended.[23,24] The UE was placed in 90° of abduction and externally rotated so the thumb was pointing toward the ceiling. The examiner placed the HHD slightly proximal to the radial styloid and used the opposite hand to stabilize the scapula.

Lower trapezius isometric strength was measured with the athlete lying prone on a treatment table, the test limb positioned over the head in 135° of abduction, and the elbow fully extended.[23,24] The thumb of the test limb was pointed toward the ceiling. The examiner placed the HHD slightly proximal to the radial styloid process and used the other hand to stabilize the scapula.

Rhomboid strength was measured with the athlete lying prone on a treatment table.[23,24] The athlete's head rested on the forearm of the nontest limb, and the test limb was positioned in 90° of abduction with the elbow extended and the thumb pointing toward the floor. The examiner placed the HHD proximal to the ulnar styloid and used the opposite hand to stabilize the scapula. Athletes were instructed to push straight upward for all measurements, with the motion coming from the muscle being tested.

Glenohumeral internal- and external-rotation strength was measured with the athlete lying prone on a treatment table[23,24] and the test limb abducted to 90°. The athlete was instructed to rotate the elbow inward or outward. The examiner stood on the side of the test limb and placed the HHD on the volar or dorsal side of the forearm, slightly proximal to the wrist.

The lower fibers of the pectoralis major were tested with the athlete lying supine on a treatment table.[16] The test limb was positioned with the shoulder abducted to 120°, the elbow fully extended, and the palm facing upward. The athlete was instructed to push up and inward toward the opposite hip while keeping the UE straight. The HHD was placed slightly proximal to the elbow.

The serratus anterior was tested with the athlete positioned short sitting on a plyometric box.[23,24] The test limb was placed in approximately 130° of flexion, the elbow was fully extended, and the palm was facing the

Table 3. Flexibility of Pitchers Versus Position Players

Measure	Mean ± SD Overall (n = 30)	Pitchers (n = 16)	Position Players (n = 14)	t_{28} Value	*P* Value
Glenohumeral internal rotation, °					
Dominant limb	65.50 ± 9.23	65.57 ± 9.06	65.42 ± 9.77	0.043	.97
Nondominant limb	71.54 ± 10.97	72.65 ± 10.99	70.27 ± 11.22	0.588	.56
Deficit	6.04 ± 8.27	7.08 ± 9.60	4.84 ± 6.60	0.734	.47
Glenohumeral external rotation, °					
Dominant limb	96.51 ± 12.74	101.14 ± 10.97	91.23 ± 12.92	2.274	.03[a]
Nondominant limb	94.13 ± 10.39	98.56 ± 8.30	89.06 ± 10.45	2.770	.01[a]
Total arc of motion, °					
Dominant limb	162.01 ± 16.55	166.71 ± 14.05	156.65 ± 18.04	1.715	.10
Nondominant limb	165.67 ± 15.54	171.21 ± 14.02	159.33 ± 15.19	2.227	.03[a]
Posterior shoulder tightness, °					
Dominant limb	106.28 ± 6.78	106.96 ± 6.05	105.52 ± 7.68	0.573	.57
Nondominant limb	109.80 ± 8.17	111.63 ± 7.94	107.71 ± 8.21	1.331	.19
Pectoralis minor length, mm					
Dominant limb	58.62 ± 8.95	57.60 ± 5.65	59.78 ± 11.80	−0.659	.52
Nondominant limb	56.98 ± 6.25	57.43 ± 6.12	56.47 ± 6.58	0.416	.68

[a] Difference between pitchers and position players ($P < .05$).

ground. The HHD was placed just proximal to the wrist. The athlete was instructed to keep the UE straight and push straight toward the ceiling.

The supraspinatus was tested with the athlete positioned short sitting on a plyometric box.[24] The test limb was abducted to 90° and horizontally adducted to 40° anterior to the coronal plane with the elbow fully extended. The HHD was placed just proximal to the wrist. The athlete was instructed to push straight upward while maintaining the position of the thumb pointing straight toward the ceiling.

The upper trapezius was tested with the athlete positioned short sitting on a plyometric box.[23,24] His hands were relaxed in his lap, and his face was turned just slightly away from the test limb. The examiner placed the HHD through a therapy strap and held it over the acromion process. The athlete was instructed to depress the shoulder before test initiation and to raise his shoulders toward his ears or shrug his shoulders upward to initiate the test.

Data Reduction

To score the KJOC questionnaire, each 10-cm line associated with the 10 questions was measured. The measurement was taken from the farthest point on the left side of the line to the *x* that was marked as a measure of the current level of performance, function, or both.[2] All measures were recorded to the nearest 0.1 cm. The measurements for all 10 questions were summed to represent an overall score for the UE level of performance, function, or both out of a total of 100. The measurements for questions 1 through 5 were summed to represent an overall score for UE pain. The measurements from questions 6 through 10 were summed to represent an overall score for UE function.

All UE isometric-strength measurements were normalized to body weight (%BW). Normalized UE isometric strength was used to calculate strength for the scapular muscle group, strength for the glenohumeral muscle group, and overall total UE strength for both the dominant and nondominant limbs.

Data Analysis

We assessed all variables for normality. All variables assessed as normal were analyzed with an independent-samples *t* test to determine if differences existed between pitchers and position players and between athletes who had or had not sustained an injury in the year before testing. For all variables that were not normally distributed, we calculated a Mann-Whitney *U* test for analyses between pitchers and position players and between athletes with or without injury in the year before testing. The α level was set a priori at .05. We used SPSS (version 24; IBM Corp, Armonk, NY) and Stata 14 (StataCorp LLC, College Station, TX) for all statistical analyses.

A stepwise multiple regression model was fit using Stata 14 to determine if the predictor variables assessed in this study could predict the KJOC scores. The predictor variables were GIRD, total arc of motion (passive glenohumeral internal and external rotation), posterior shoulder tightness, total strength of the scapular muscles, total strength of the glenohumeral muscles, and total strength of the entire shoulder complex. The response variables were the KJOC total score, KJOC total score for questions 1 through 5, and KJOC total score for questions 6 through 10. We used the Pearson product moment correlation for normal variables and the Spearman rank correlation for nonnormal variables to determine if any relationships existed between the predictor variables and response variables chosen for this study. We calculated β coefficients to assess the relative predictive power of each predictor variable. We set the α level at .10 to determine which of the predictor variables would be included in the final regression model.

RESULTS

Means and standard deviations (SDs) for all baseball athletes and for baseball athletes stratified by position and UE injury history are presented in Tables 3 through 6 and Supplemental Tables 1 through 4 (available online at http://dx.doi.org/10.4085/1062-6050-81-18.S1). These data pro-

Table 4. **Flexibility of Injured Versus Uninjured Players**

Measure	Mean ± SD			
	Injured Players (n = 5)	Uninjured Players (n = 25)	t_{28} Value	P Value
Glenohumeral internal rotation, °				
Dominant limb	67.22 ± 10.60	65.16 ± 9.14	−0.450	.66
Nondominant limb	78.51 ± 14.18	70.15 ± 9.99	−1.596	.12
Deficit	11.29 ± 8.67	4.99 ± 7.96	−1.595	.12
Glenohumeral external rotation, °				
Dominant limb	95.07 ± 4.06	96.02 ± 13.80	−0.823	.42
Nondominant limb	98.96 ± 5.07	93.94 ± 11.29	−0.218	.83
Total arc of motion, °				
Dominant limb	173.57 ± 12.97	161.18 ± 17.91	−1.123	.28
Nondominant limb	166.18 ± 5.93	164.08 ± 15.25	−1.259	.22
Posterior shoulder tightness, °				
Dominant limb	108.09 ± 8.07	106.37 ± 6.77	0.159	.88
Nondominant limb	105.84 ± 7.62	110.14 ± 8.31	0.508	.62
Pectoralis minor length, mm				
Dominant limb	57.65 ± 5.24	59.71 ± 9.30	1.518	.14
Nondominant limb	53.19 ± 4.21	56.85 ± 6.52	−0.256	.80

vide a reference dataset describing posture and UE ROM, flexibility, and strength in Division I collegiate baseball athletes. Pairwise correlations between the response variables and the predictor variables selected for this study are presented in Table 7. We observed no correlations between the predictor and response variables.

Multiple linear regression models that retained predictor variables are presented in Tables 8 and 9. Based on the multiple linear regression model, 1 predictor variable was maintained in the final equation for the response variable KJOC total score: history of UE injury in the year before testing. This multiple linear regression model accounted for 7.80% of the variance in KJOC total score ($P = .07$). Based on the multiple linear regression model, 2 predictor variables were maintained in the final equation for the response variable KJOC total score for questions 1 through 5: history of UE injury in the year before testing and posterior shoulder tightness. This multiple linear regression model accounted for 14.40% of the variance in KJOC total score for questions 1 through 5 ($P = .047$). The multiple linear regression model retained no predictor variables for KJOC total score for questions 6 through 10.

Normalized β coefficients for the multiple linear regression model are presented in Table 10. The β coefficients showed that, for every 1-SD increase in UE injury history, the predicted decrease of the KJOC total score would be 0.297 SD. For the total of questions 1 through 5 of the KJOC score, the greatest effect was observed with posterior shoulder tightness. For every 1-SD increase in posterior shoulder tightness, a decrease of 0.348 SD in the KJOC total score for questions 1 through 5 would be expected.

Table 6. **Kerlan-Jobe Orthopaedic Clinic Score Questionnaire for Injured and Uninjured Players**

Kerlan-Jobe Orthopaedic Clinic Score Question(s)	Mean ± SD			
	Injured Players (n = 5)	Uninjured Players (n = 25)	t_{28} Value	P Value
1	7.74 ± 2.45	9.16 ± 1.34	1.264	.27
2	7.92 ± 2.48	9.27 ± 1.02	1.200	.29
3	8.46 ± 2.82	9.07 ± 1.79	0.634	.53
4	7.88 ± 2.91	9.46 ± 1.10	1.199	.29
5	9.78 ± 0.49	9.85 ± 0.52	0.269	.79
1–5 (Total)	41.78 ± 10.10	46.82 ± 4.10	1.097	.33
6	9.34 ± 1.26	9.52 ± 1.50	0.245	.81
7	8.28 ± 3.03	9.50 ± 0.86	0.895	.42
8	8.10 ± 3.57	9.47 ± 0.90	0.852	.44
9	9.32 ± 1.52	9.66 ± 0.67	0.485	.65
10	8.48 ± 2.73	9.76 ± 0.63	1.043	.36
6–10 (Total)	43.52 ± 12.08	47.90 ± 0.01	0.806	.46
1–10 (Total)	85.30 ± 21.88	94.74 ± 6.79	0.956	.39

DISCUSSION

Perceived UE pain and function, as measured by the KJOC questionnaire, has not been linked to UE musculoskeletal characteristics, including posture, ROM, flexibility, and strength. Ultimately, this may allow for better discrimination among baseball athletes who do not have any UE pain, are playing with UE pain, or are not playing due to UE pain. Therefore, the primary purpose of our study was to describe the musculoskeletal characteristics of the

Table 5. **Kerlan-Jobe Orthopaedic Clinic Scores for Pitchers and Position Players**

Kerlan-Jobe Orthopaedic Clinic Score Question(s)	Mean ± SD				
	Overall (n = 30)	Pitchers (n = 16)	Position Players (n = 14)	t_{28} Value	P Value
1	8.93 ± 1.61	8.64 ± 2.02	9.25 ± 0.94	−1.074	.29
2	9.05 ± 1.41	8.80 ± 1.69	9.33 ± 0.99	−1.028	.31
3	8.97 ± 1.95	8.72 ± 2.19	9.26 ± 1.67	−0.749	.46
4	9.20 ± 1.59	9.13 ± 1.67	9.28 ± 1.55	−0.260	.80
5	9.84 ± 0.51	9.78 ± 0.64	9.90 ± 0.30	−0.633	.53
1–5 (Total)	45.98 ± 5.62	45.07 ± 6.63	47.01 ± 4.21	−0.944	.35
6	9.49 ± 1.44	9.60 ± 0.87	9.36 ± 1.93	0.453	.65
7	9.30 ± 1.45	8.96 ± 1.87	9.69 ± 0.60	−1.412	.17
8	9.24 ± 1.64	9.03 ± 2.03	9.48 ± 1.08	−0.738	.47
9	9.60 ± 0.84	9.29 ± 1.07	9.95 ± 0.16	−2.428	.03[a]
10	9.55 ± 1.26	9.29 ± 1.68	9.84 ± 0.37	−1.260	.23
6–10 (Total)	47.17 ± 5.52	46.18 ± 6.96	48.31 ± 3.04	−1.062	.30
1–10 (Total)	93.17 ± 10.82	91.28 ± 13.21	95.33 ± 7.09	−1.023	.32

[a] Difference between pitchers and position players ($P < .05$).

Table 7. **Correlation Coefficients**

	Kerlan-Jobe Orthopaedic Clinic Score Questionnaire					
	Total		Total for Questions 1–5		Total for Questions 6–10	
Measure	Correlation Coefficient	*P* Value	Correlation Coefficient	*P* Value	Correlation Coefficient	*P* Value
Glenohumeral internal-rotation deficit	−0.190	.32	−0.134	.48	−0.235	.21
Total arc of motion	−0.156	.41	−0.199	.29	−0.107	.57
Posterior shoulder tightness	−0.236	.21	−0.286	.13	−0.176	.35
Total strength						
Scapular muscles	0.043	.82	0.022	.91	0.058	.76
Glenohumeral muscles	−0.026	.89	−0.049	.80	−0.006	.98
Shoulder complex	−0.006	.98	−0.029	.88	0.014	.94

UE—posture, ROM, flexibility, and isometric strength—in a population of baseball athletes and to further analyze potential differences between player position and injury history. The secondary purpose of our study was to determine if these musculoskeletal characteristics had predictive capability for the KJOC scores of baseball athletes.

Our results demonstrated differences in the musculoskeletal characteristics of the UE when the baseball population was stratified by position and 1-year injury history. We also observed a relationship between KJOC total score for questions 1 through 5 and a history of UE musculoskeletal injury and posterior shoulder tightness. The hypothesis that predictive capabilities would be present between posture, UE ROM, flexibility, and isometric strength and the KJOC questionnaire score was partially supported, and both UE musculoskeletal injury history in the past year and posterior shoulder tightness were partially predictive of the KJOC score.

Comparisons of UE musculoskeletal characteristics between pitchers and position players illustrated group differences. Based on averages, pitchers demonstrated less forward shoulder posture in the dominant shoulder than position players. A forward shoulder posture may be attributed to imbalances in the strength of the scapular-stabilizer muscles, tightness, or both in the anterior shoulder musculature.[17–19] Comparisons of ROM and flexibility between pitchers and position players revealed differences in external-rotation ROM and, subsequently, total arc of motion. Pitchers displayed greater external-rotation ROM and total arc of motion than position players. Greater external-rotation ROM has been noted in pitchers and may be due to bony and muscular adaptations that have been attributed to the pitching motion.[16] Generally, pitchers demonstrated less UE strength than position players. These differences were evident in the strength of the middle and lower trapezius, rhomboid, and serratus anterior and the calculated total strength for the scapular muscles. Less strength in pitchers may be explained by a lack of focus on pure strengthening exercises to preserve the shoulder for pitching activities. A certain level of strength must be maintained to achieve optimal performance, but the fatigue caused by repetitive overhead throwing may affect pitchers' ability to perform effective strength training.[4,7] In addition to strength, athletes must maintain the muscular endurance necessary to overcome the fatigue associated with the throwing motion.

The KJOC questionnaire was developed to assess the functional status of the UE, specifically in athletes who participate in overhead sports.[2,25] Traditional methods of examining pain, including the Disabilities of the Arm, Shoulder and Hand questionnaire, do not satisfy the need to assess sport-specific characteristics,[2,25,26] including subtle changes in endurance, velocity, power, and ball control.[25] Researchers[3,25,26] have reported that the KJOC score can distinguish among professional baseball athletes who do not have pain, are playing with pain, or are not playing due to pain. A KJOC score threshold of 81.3 is more sensitive and accurate than the threshold for other questionnaires used to assess the UE.[26] A KJOC score greater than 81.3 indicates with 95.1% accuracy that a patient has returned to play.[26] The total KJOC score for all baseball athletes tested in our study was 93.17, indicating that these athletes scored above the return-to-play standard as assessed by the KJOC questionnaire. The pitchers in our study scored just slightly lower than the position players (KJOC scores = 91.28 and 95.33, respectively). We found greater differences between athletes who did or did not have a history of UE musculoskeletal injury in the year before testing (KJOC scores = 85.30 and 94.74, respectively). The baseball athletes who had a history of UE musculoskeletal injury in the year before testing scored just slightly higher than the KJOC score used as a return-to-play criterion. The direct relationship between a 1-year history of UE musculoskel-

Table 8. **Regression Model for Kerlan-Jobe Orthopaedic Clinic Total Score**

Source	Sum of Squares	Degrees of Freedom	Mean Square	Observations	$F_{1,28}$ Value	*P* Value	R^2	Adjusted R^2	Root Mean Square Error
Model	371.621	1	371.621	30	3.440	.07	0.110	0.078	10.388
Residual	3021.642	28	107.916						
Total	3393.263	29	117.009						
Predictor Variables	Coefficient	*t* Value	*P* Value						
Upper extremity injury history	−9.444	−1.860	.07						
(Constant)	94.744	45.600	<.001						

Table 9. Regression Model for Kerlan-Jobe Orthopaedic Clinic Total Score for Questions 1–5

Source	Sum of Squares	Degrees of Freedom	Mean Square	Observations	$F_{1,28}$ Value	*P* Value	R^2	Adjusted R^2	Root Mean Square Error
Model	186.412	2	93.206	30	3.440	.047	0.203	0.144	5.202
Residual	730.522	27	27.056						
Total	916.934	29	31.618						
Predictor Variables	Coefficient	*t* Value	*P* Value						
Upper extremity injury history	−5.168	−2.030	.05						
Posterior shoulder tightness	−0.246	−1.730	.10						
(Constant)	73.011	4.800	<.001						

etal injury in baseball athletes and the resultant KJOC score may indicate a need to address pain and self-perceived performance in athletes who are rehabilitating after UE musculoskeletal injury. Obtaining baseline KJOC scores before a UE musculoskeletal injury event may allow for more individualized clinical care and return-to-play decisions. Baseline KJOC scores can be compared with all subsequent KJOC scores to determine an individual KJOC score threshold for return to play after UE musculoskeletal injury.

The most common pain in the UE occurs in the glenohumeral joint and has been reported by 32% of pitchers in 7% of pitching appearances.[4] Glenohumeral joint pain has been associated with changes in UE ROM and flexibility, UE strength, limb fatigue, and decreased self-perceived performance.[4] We demonstrated that a 1-year history of UE musculoskeletal injury and posterior shoulder tightness were related to the KJOC total score for questions 1 through 5. The relationship between UE musculoskeletal injury and the KJOC score indicated that, after UE musculoskeletal injury, changes in pain and function of the UE were likely to occur. This may be due to the UE musculoskeletal characteristics not meeting optimal functional levels after UE musculoskeletal injury, translating to pain, limb fatigue, and decreased self-perceived performance. Athletes with a 1-year history of UE musculoskeletal injury scored consistently lower on the KJOC questionnaire than athletes who did not report such a history. This highlights the continued need for injury rehabilitation and prevention programs after return-to-play criteria have been met and athletes have returned to full participation in baseball activity. The relationship between posterior shoulder tightness and the KJOC score emphasizes the importance of continued participation in ROM and flexibility-training programs throughout a baseball athlete's career, as well as after UE musculoskeletal injury. Interestingly, strength was not related to the KJOC score, which may suggest that unilateral strength was not necessarily related to changes in the KJOC score. In baseball athletes, determining whether differences exist between the dominant and nondominant UEs and examining these differences as they relate to the KJOC score may be important.

Table 10. Beta Coefficents for the Kerlan-Jobe Orthopaedic Clinic Score

Variable	Total	Total for Questions 1–5
Upper extremity injury history	−0.297	−0.331
Posterior shoulder tightness	Not applicable	−0.348

We acknowledge that our study had inherent limitations. Changes in the musculoskeletal characteristics of the UE, pain, function, and self-perceived performance may be directly related to the type of UE injury sustained. For this study, all injuries were categorized as general UE musculoskeletal injuries, regardless of the type or location. This general categorization may have affected the predictive capability of a 1-year history of UE musculoskeletal injury on the KJOC score. The outcomes may change when UE musculoskeletal injuries are stratified by location or injury severity; researchers should examine this possibility, which would require a larger sample size and a greater number of UE musculoskeletal injuries than were available in our study. We also did not assess the strength of the individual UE muscles. Instead, we summed the strength of the individual UE muscles to calculate the strength of the scapular and glenohumeral muscle groups and overall UE strength. Addressing the relationship between each UE muscle's strength and the KJOC score may be necessary to determine how different injury types affect the KJOC score. Lastly, the statistical analysis included multiple *t* tests, which we acknowledge may have increased the risk of a type 1 error.

CONCLUSIONS

Upper extremity musculoskeletal pain and injury are common in baseball athletes[1,3,4,7,26] and may negatively affect player safety and performance.[3,4,7,26] Our results demonstrated that a 1-year history of UE musculoskeletal injury and posterior shoulder tightness were predictive of the KJOC total score for questions 1 through 5 in baseball athletes. These results highlight the need for a continued focus on self-perceived pain, function, and performance after UE musculoskeletal injury. Therefore, when baseball athletes return to sport after UE injury, clinicians need to screen for continuing pain and diminished self-perceived performance. Upper extremity injury-prevention and rehabilitation programs should be aimed at caring for each athlete's physical and mental wellbeing to provide the most effective treatment.

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SUPPLEMENTAL MATERIAL

Supplemental Tables. Posture and strength of pitchers versus position players; Posture and strength of injured versus uninjured players.

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Address correspondence to Mallory S. Faherty, PhD, LAT, ATC, Michael W. Kryzyzewski Human Performance Laboratory, Department of Orthpaedic Surgery, Duke University, 345 Erwin Road, Durham, NC 27705. Address e-mail to mallory.faherty@duke.edu.