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Title:

Comparison of KJOC Scores in College Athletes With and Without Arm Trouble Across Overhead Sports

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Abstract

Context: Shoulder and elbow problems are common among athletes in overhead sports, making it essential to understand the characteristics of active athletes with arm trouble to improve and prevent upper extremity disorders. The Kerlan-Jobe Orthopaedic Clinic (KJOC) Score is widely used to evaluate upper extremity functionality in this population.

Objective: (1) To compare the KJOC score between athletes with and without arm trouble in various overhead sports; and (2) to clarify the relationship between subjective competitive levels and functional characteristics using correlation analysis of the KJOC score questions.

Design: Cross-sectional study

Setting: College athletes from baseball, basketball, swimming, tennis, and track and field throwing teams completed the KJOC score questionnaire. Participants were categorized into two groups based on their responses regarding current functional status: (1) playing without arm trouble (asymptomatic group) and (2) playing with arm trouble (symptomatic group).

Participants: 401 college athletes from overhead sports.

Main Outcome Measure(s): The Mann–Whitney U test was used to compare the overall KJOC

scores and the scores of individual questions between symptomatic and asymptomatic groups. Spearman's rank correlation analysis determined the relationships between Q10 (subjective competitive level) and Q1–9 (upper extremity functionality).

Results: The symptomatic group had significantly lower KJOC scores than the asymptomatic group across all sports ($P < 0.001$). Several individual question scores also differed significantly between groups, although the specific questions varied by sport. Correlation analysis revealed the association between Q10 and other functional scores with sport-specific variations.

Conclusions: These findings demonstrate that impaired upper extremity function and its relationship to competition levels in athletes with arm trouble vary across different sports disciplines.

Key Words: KJOC score, upper extremity, function, sports

Key Points

- Athletes with arm trouble exhibited lower KJOC scores compared to those without arm trouble.
- Impairments in upper extremity function varied among athletes with arm trouble across sports disciplines.
- Association between upper extremity functionality and subjective competitive levels differed across sports disciplines.

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Shoulder and elbow problems are common among athletes in various overhead sports, including baseball, tennis, swimming, track and field throwing, and basketball.[1-10] However, some athletes continue participating in their sports despite experiencing upper extremity issues.[11,12] Understanding the characteristics of athletes who play with arm trouble is crucial for improving management strategies and preventing the worsening of these conditions.

The Kerlan-Jobe Orthopaedic Clinic Shoulder and Elbow (KJOC) score was developed to assess shoulder and elbow function in overhead sports athletes.[13] Previous studies have shown that the KJOC score effectively evaluates subtle changes in shoulder and elbow functionality.[11,14] Additionally, the KJOC score includes an unscored question about playing conditions, allowing athletes to be categorized into three groups: playing without issues, playing with arm trouble, and not playing due to arm trouble. Comparing the KJOC scores of athletes in these groups can help clarify the functional characteristics of those playing with arm trouble ~~problems~~. Furthermore, analyzing the KJOC scores across various overhead sports can offer insight into sport-specific factors that influence the management of arm problems.

Moreover, functional characteristics related to changes in subjective competitive levels due to arm trouble are of significant interest to athletes, coaches, and medical staff. The KJOC score includes a question that assesses how much athletes believe their arm affects their current competitive performance.[13] Previous research has demonstrated good to excellent internal consistency across the KJOC questions.[13,15-22] However, the correlations among these questions

in athletes with upper extremity trouble remain unclear. This study aims to provide new insights into the functional factors influencing subjective competitive levels through a correlation analysis between the question on competitive performance and the other KJOC questions.

The primary aim of this study was to compare the KJOC scores of college athletes with and without arm trouble across various overhead sports, including baseball, basketball, swimming, tennis, and track and field throwing. A secondary objective was to examine the relationship between subjective competitive levels and functional characteristics in college athletes with arm trouble in each sport by analyzing correlations among KJOC questions.

Methods

Participants recruitment

Participants for this study were recruited from college athletes playing overhead sports, including baseball, basketball, swimming, tennis, and track and field throwing (javelin throw, shot put, and disc throw). Recruitment occurred from regional league or national level teams between June 2022 and June 2024. Coaches, athletic trainers, and physical therapists from each team explained the purpose of the study and invited athletes to participate by completing the KJOC score. Completing the KJOC score was considered an agreement to participate in the study. Athletes not playing their sports due to arm trouble were excluded from the study participants. This study was approved by the Institutional Ethical Review Board.

KJOC score

Participants completed the KJOC score, a tool used to assess upper extremity functionality. The assessment consists of 10 questions, each answered by marking a 100 mm visual analog scale. Because the location of each mark was rigorously measured in millimeters using a digital caliper, an average of the 10 items was calculated to determine the final KJOC score, which ranges from 0 to 100. Higher KJOC scores indicate better upper extremity functionality. Additionally, the KJOC score includes unscored questions that assess current functional status. Based on these unscored questions, participants were categorized into three groups: (1) playing without arm trouble (asymptomatic group), (2) playing with arm trouble (symptomatic group), and (3) not playing due to arm trouble. The athletes who answered not playing due to arm trouble were excluded from this study.

Statistical analysis

Through normality examination using the Shapiro–Wilk test, our data showed a non-normal distribution. Consequently, the Mann–Whitney U test was used to compare KJOC scores, as well as individual question scores, between asymptomatic and symptomatic groups within each overhead sports discipline. Furthermore, a comparison between the group differences and minimal detectable change (MDC) was conducted to ensure whether the group

differences were within measurement errors. The MDCs were calculated in our previous study.[17] To analyze the relationship between subjective competitive level and upper extremity functionality, we performed multiple correlation analyses using ~~a~~ Spearman rank correlation coefficients to assess the correlation between Q10 (subjective competitive level) and Q1–Q9 (upper extremity functionality). Based on a previous study,[23] correlation coefficients were classified as follows: 0.00–0.10 (negligible), 0.10–0.39 (weak), 0.40–0.69 (moderate), 0.70–0.89 (strong), 0.90–1.00 (very strong). All statistical procedures were conducted using SPSS Statistics Version 29 (IBM Corp) with statistical significance set at $P < 0.05$.

Results

We obtained responses to the KJOC scores from 401 eligible college athletes in overhead sports. Table 1 summarizes the demographic data of the participants. Overall, approximately 20% of the athletes played their sports with arm troubles. The proportion of athletes with arm troubles was approximately 7% in basketball, 13% in tennis, 20% in track and field throwing and swimming, and 60% in baseball.

Table 2 shows the results of the KJOC score and each question. In all sports disciplines, athletes with arm trouble had significantly lower KJOC scores than athletes without arm trouble ($P < 0.001$ for every sport, mean difference: 24.5 for baseball, 20.5 for basketball, 23.3 for swimming, 24.9 for tennis, and 22.7 for track and field throwing). The difference in KJOC

scores between athletes with and without arm trouble exceeded the MDC (13.2) reported in a previous study[17] in each sport.

Question 1: How difficult is it for you to get loose or warm prior to competition or practice?

We found a significant difference in Q1 between athletes with and without arm trouble in baseball ($P < 0.001$), swimming ($P = 0.002$), and track and field throwing ($P = 0.007$). However, the average differences (20.3 for baseball, 11.0 for swimming, and 15.5 for track and field throwing) did not exceed the MDC (39.7) [17].

Question 2: How much pain do you experience in your shoulder or elbow?

We found a significant difference in between athletes with and without arm trouble in every sports discipline ($P < 0.001$ for every sport). The average group differences in Q2 scores exceeded the MDC (31.3) [17] in all sports disciplines (36.8 for baseball, 36.0 for basketball, 42.0 for swimming, 55.0 for tennis, and 45.5 for track and field throwing).

Question 3: How much weakness and/or fatigue (i.e., loss of strength) do you experience in your shoulder or elbow?

We found a significant difference in Q3 between athletes with and without arm trouble in all sports disciplines ($P = 0.006$ for baseball, $P = 0.01$ for basketball, $P < 0.001$ for swimming, $P = 0.003$ for tennis, and $P = 0.002$ for track and field throwing). However, the MDC for Q3 (30.5) [17] was higher than the average differences between groups (19.9 for baseball, 13.7 for basketball, 27.5 for swimming, 25.2 for tennis, and 26.8 for track and field throwing).

Question 4: How unstable does your shoulder or elbow feel during competition?

We found significant differences in Q4 between athletes with and without arm trouble in every sports discipline ($P = 0.002$ for baseball, $P < 0.001$ for basketball, $P < 0.001$ for swimming, $P = 0.003$ for tennis, and $P < 0.001$ for track and field throwing). However, only basketball (30.6) and track and field throwing (31.0) showed higher average group differences than the MDC (30.2) [17].

Question 5: How much have arm problem affected your relationship with your coaches, management, and agents?

No significant differences were observed in Q5 between athletes with and without arm trouble across all sports.

Question 6: How much have you had to change your throwing motion, serve, stroke, etc, due to your arm?

We found significant differences in Q6 between athletes with and without arm trouble in every sport ($P = 0.003$ for baseball, $P < 0.001$ for basketball, $P < 0.001$ for swimming, $P = 0.012$ for tennis, $P = 0.001$ for track and field throwing). However, only basketball (26.7) and tennis (27.6) players showed higher average group differences than the MDC for Q6 (25.2). [17]

Question 7: How much has your velocity and/or power suffered due to your arm?

We found significant differences in Q7 between athletes with and without arm trouble ~~groups~~ in every sport ($P = 0.003$ for baseball, $P = 0.001$ for basketball, $P < 0.001$ for swimming,

$P = 0.012$ for tennis, and $P = 0.001$ for track and field throwing). However, the average group differences in Q7 exceeded the MDC (25.7) [17] in baseball (31.3) and tennis (31.9).–

Question 8: What limitation do you have in endurance in competition due to your arm?

We found significant differences in Q8 between athletes with and without arm trouble in baseball ($P < 0.001$), swimming ($P < 0.001$), and tennis ($P = 0.002$). The average differences between groups are also exceeded the MDC (22.3) [17] in baseball (33.0), swimming (24.3), and tennis (28.9).

Question 9: How much has your control (of pitches, serves, strokes, etc.) suffered due to your arm?

We found significant differences in Q9 between athletes with and without arm trouble in baseball ($P = 0.02$), basketball ($P < 0.001$), swimming ($P < 0.001$), and track and field throwing ($P = 0.008$). The sports disciplines that showed differences beyond the MDC (21.3) [17] were basketball (29.3) and swimming (27.3).

Question 10: How much do you feel your arm affects your current level of competition in your sport (i.e., is your arm holding you back from being at your full potential)?

We found significant differences in Q10 between athletes with and without arm trouble in every sport ($P = 0.003$ for baseball, $P = 0.012$ for basketball, $P < 0.001$ for swimming, $P = 0.012$ for tennis, and $P = 0.001$ for track and field throwing). The average group differences also exceeded the MDC (25.8) [17] in baseball (34.3), tennis (26.3), and track and field throwing

(30.5).

Table 3 shows the correlation coefficients between the score of Q10 and each question in athletes with arm trouble. In baseball players, Q10 showed a strong relationship with Q7, a moderately significant relationship with Q6, Q8, and Q9, and weak relationships with Q2 and Q3. In basketball players, Q10 showed strong relationships with Q3 and Q8. In swimmers, Q10 showed a moderate association with Q4, Q7, and Q9 and a strong relationship with Q8. In tennis players, Q10 displayed moderate relationships with Q7, strong relationships with Q3, Q4, and Q6, and very strong relationships with Q8. In track and field throwing athletes, Q10 showed a very strong relationship with Q7, while moderate relationships were found with Q2, Q3, Q4, and Q6.

Discussion

Our study revealed that athletes with arm trouble had significantly lower KJOC scores than athletes without arm trouble across various overhead sports. The average differences between athletes with and without arm trouble exceeded the MDC. Consistent with our findings, previous studies also showed that baseball and swimming athletes with arm trouble had lower KJOC scores than those without arm trouble.[11,12,24] Our results indicate that overall upper extremity function, as evaluated by the KJOC score, is lower in athletes with arm trouble than those without arm trouble.

194 However, the specific questions that received low scores in athletes with arm trouble
195 varied by sport. In our study, baseball players with arm trouble reported decreases in power and
196 endurance capacity. Basketball players with arm trouble reported shoulder and elbow instability,
197 the need to change their motion, and reduced control. Swimmers with arm trouble experienced
198 reduced endurance capacity and control of strokes. Tennis players with arm trouble felt the need
199 to change their motion, along with decreased power and endurance capacity. Track and field
200 throwing athletes with arm trouble reported shoulder and elbow instability. These findings
201 suggest that athletes with arm trouble likely experience different disabilities depending on their
202 sports. For instance, athletes with arm trouble in baseball, swimming, and tennis reported
203 decreases in endurance capacity. Considering that athletes playing these sports displayed a high
204 incidence of overuse injuries such as shoulder and elbow tendinopathy,[25] decreases in
205 endurance capacity may escalate the risk of overuse injuries. Upper extremity injuries account
206 for 2.8% to 14.1% of injuries in basketball,[10] indicating that basketball places relatively less
207 demand on the upper extremities. Track and field throwing athletes with arm trouble displayed
208 significant reduction beyond the MDC in a question regarding joint instability (Q4). A previous
209 study found that tendon and ligament injury account for over 60% of all injuries in track and
210 field throwing athletes, leading to joint instability. [26] Therefore, joint instabilities in these
211 athletes may stem from tendon or ligament injuries. Previous [10,25,26] and current findings
212 indicate that athletes with arm trouble experience various functional limitations depending on

their respective sports. Hence, daily training and warm-up programs should be specifically tailored to each sport. Additionally, our results suggest that different sports have unique factors that need to be addressed in managing athletes with arm trouble.

A study developing the KJOC score displayed high correlations among its items,[13] and cross-cultural adaptation studies of the KJOC score also showed good to excellent internal consistency.[15-21] However, the results of correlation analysis in our study indicate that factors related to subjective competitive levels vary across sports disciplines in athletes with arm trouble. In baseball players with arm trouble, subjective competitive levels were associated with pain, weakness/fatigue, altered motion, diminished power, decreased endurance capacity, and reduced control. In basketball players with arm trouble, subjective competitive levels were associated with weakness/fatigue and endurance capacity. In swimming athletes with arm trouble, subjective competitive levels were associated with joint instability, diminished power, decreased endurance capacity, and reduced control. In tennis players with arm trouble, subjective competitive levels were associated with weakness/fatigue, joint instability, altered motion, diminished power, and reduced control. In track and field throwing athletes with arm trouble, subjective competitive levels were associated with weakness/fatigue, joint stability, altered motion, diminished power, and reduced control. This study suggests that coaches, athletic trainers, physical therapists, and other team members should consider sport-specific declines in upper extremity function that are associated with lower subjective competitive levels.

For instance, since weakness/fatigue is associated with competitive levels in most sports except swimming, improving competitive levels might be possible by allowing for appropriate rest and recovery.

When comparing the score of each question between athletes with and without arm trouble, pain (Q2) was significantly lower in athletes with arm trouble across all sports disciplines. The mean difference in Q2 scores between athletes with and without arm trouble exceeded the MDC. Previous studies reported that musculoskeletal pain diminishes exercise performance levels.[27,28] Contrary to this, the pain score showed no relationship with subjective competition levels in athletes playing with arm trouble except baseball players and track and field throwing athletes. This result suggests that pain may not be directly associated with competitive levels, although most athletes with arm trouble experience pain in their shoulder or elbow. However, since pain aggravation can lead to disqualification of competitive athletes, functional characteristics associated with subjective competition levels, besides pain, may serve as compensatory strategies to manage or distract from pain. Therefore, paying attention to the functional characteristics related to competitive levels is important for improving performance and preventing pain aggravation.

Our current study has some limitations. First, the timing of completing the questionnaire varied between the off-season and competitive season across different sports disciplines. Future studies should investigate prospective changes in the KJOC score over time.

Second, the number of athletes with arm trouble was small in certain sports, such as basketball and tennis, which limit the generalizability of the findings. Third, we did not analyze sex differences, as males and females were evaluated together. Future research should examine the characteristics of male and female overhead athletes with arm trouble separately.

In conclusion, this study compared KJOC scores between college athletes with and without arm trouble across various sports disciplines and found significant differences in all cases. However, the questions that showed significant differences exceeding the MDC varied by sports. Furthermore, our study revealed differences in the factors associated with subjective competitive levels among sports. These findings demonstrate that impaired upper extremity function and its relationship to competitive levels in athletes with arm trouble vary across sports disciplines. Therefore, coaches, athletic trainers, physical therapists, and other team staff members should manage and improve upper extremity function by considering sport-specific characteristics.

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Table 1. Demographic data of the participants (mean ± standard deviations)

	No. of athletes (males, females, non-answered)	Age (y)	No. of symptomatic athletes	No. of asymptomatic athletes
All athletes	401 (274, 123, 4)		88	313
Baseball	61 (51, 10, 0)	19.7 ± 1.1	36	25
Basketball	111 (58, 53, 0)	19.4 ± 1.0	8	103
Swimming	71 (49, 21, 1)	19.5 ± 1.3	17	54
Tennis	81 (62, 17, 2)	19.4 ± 1.1	11	70
Track and field throwing	77 (54, 22, 1)	19.4 ± 1.4	16	61

Table 2. KJOC score in symptomatic and asymptomatic athletes (mean ± standard deviations)

	Baseball		Basketball		Swimming		Tennis		Track and field throwing	
	Symp	Asymp	Symp	Asymp	Symp	Asymp	Symp	Asymp	Symp	Asymp
Ave.	**64.5 ± 17.6**	**89.0 ± 10.7**	**75.9 ± 16.7**	**96.4 ± 5.9**	**69.0 ± 17.6**	**92.3 ± 9.9**	**66.9 ± 23.4**	**91.1 ± 10.9**	**70.1 ± 19.4**	**93.8 ± 9.2**
1	**63.0 ± 25.2**	**83.3 ± 15.3**	77 ± 26.8	87.7 ± 19.5	**73.8 ± 19.8**	**84.8 ± 18.5**	75.8 ± 20.1	83.3 ± 19.6	**68.8 ± 24.9**	**84.4 ± 20.7**
2	**50.1 ± 23.7**	**86.9 ± 16.8**	**61.4 ± 24.1**	**97.4 ± 8.1**	**51.4 ± 26.5**	**93.4 ± 11.0**	**39.4 ± 21.8**	**94.3 ± 11.0**	**47.3 ± 28.1**	**92.8 ± 14.4**
3	**69.4 ± 21.9**	**89.4 ± 12.3**	**80.6 ± 15.8**	**94.3 ± 12.3**	**63.7 ± 22.0**	**91.2 ± 13.0**	**62.7 ± 26.6**	**87.9 ± 17.8**	**65.4 ± 25.4**	**92.2 ± 13.6**
4	**61.5 ± 27.4**	**83.9 ± 19.3**	**66.7 ± 27.4**	**97.3 ± 7.6**	**61.7 ± 28.4**	**88.5 ± 18.9**	**62.3 ± 29.5**	**90.1 ± 15.9**	**62.5 ± 26.3**	**93.5 ± 12.1**
5	93.9 ± 13	96.9 ± 6.3	95.6 ± 6.6	99.1 ± 2.3	91.8 ± 18.0	96.0 ± 9.3	92.8 ± 18.8	95.6 ± 11.3	99.1 ± 1.7	96.1 ± 10.9

6	**66.5 ± 32.8**	**90.2 ± 12.7**	**98.0 ± 5.5**	**71.3 ± 22.3**	**74.1 ± 25.1**	**94.8 ± 11.7**	**64.7 ± 37.4**	**92.3 ± 15.5**	**70.2 ± 25.3**	**92.8 ± 16.3**
7	**58.4 ± 29.2**	**89.7 ± 14.6**	**97.2 ± 8.3**	**76 ± 18.6**	**68.6 ± 25.9**	**92.6 ± 13.6**	**61.2 ± 34.4**	**93.2 ± 13.5**	**67.6 ± 32.3**	**92.8 ± 18.4**
8	**56.4 ± 32.8**	**89.4 ± 16.1**	98.0 ± 6.9	81.3 ± 25.6	**68.9 ± 28.1**	**93.3 ± 13.7**	**65.4 ± 32.7**	**94.4 ± 12.9**	78.8 ± 34	95.5 ± 13.1
9	**69.7 ± 32.8**	**89.5 ± 15.9**	**98.1 ± 7.1**	**68.8 ± 32.2**	**68.9 ± 28.2**	**95.3 ± 11.4**	77.4 ± 30.9	93.9 ± 12.4	**77.2 ± 29.8**	**93.6 ± 16.3**
10	**56.6 ± 26.3**	**90.9 ± 12.3**	**97.5 ± 7.3**	**80.3 ± 21.7**	**68.0 ± 26.8**	**93.3 ± 11.7**	**67.4 ± 30.5**	**93.7 ± 12.5**	**64.2 ± 30.1**	**94.6 ± 11.3**

[a]MDC: Minimal detectable change

[b]Bold black letter in gray color cell: Significant difference between symptomatic and asymptomatic athletes ($P < 0.05$)

[c]Bold white letter in black color cell: Significant difference between symptomatic and asymptomatic athletes ($P < 0.05$) and higher group difference than MDC

Table 3. Correlation coefficient between the score of Q10 and other questions in symptomatic athletes of each sport

	Baseball	Basketball	Swimming	Tennis	Track and field throwing
Q1	r = 0.181, P = 0.290	r = 0.307, P = 0.460	r = 0.361, P = 0.154	r = 0.407, P = 0.214	r = 0.313, P = 0.238
Q2	**r = 0.331, P = 0.049**	r = 0.355, P = 0.388	r = 0.335, P = 0.189	r = 0.505, P = 0.113	**r = 0.546, P = 0.029**
Q3	**r = 0.387, P = 0.020**	**r = 0.778, P = 0.023**	r = 0.166, P = 0.525	**r = 0.817, P = 0.002**	**r = 0.682, P = 0.004**
Q4	r = 0.172, P = 0.315	r = 0.584, P = 0.128	**r = 0.533, P = 0.027**	**r = 0.920, P < 0.001**	**r = 0.640, P = 0.008**
Q5	r = -0.031, P = 0.856	r = 0.247, P = 0.555	r = 0.254, P = 0.326	r = 0.138, P = 0.685	r = -0.051, P = 0.852
Q6	**r = 0.411, P = 0.013**	r = 0.635, P = 0091	r = 0.456, P = 0.066	**r = 0.713, P = 0.014**	**r = 0.581, P = 0.018**
Q7	**r = 0.713, P < 0.001**	r = 0.307, P = 0.460	**r = 0.632, P = 0.007**	**r = 0.641, P = 0.034**	**r = 0.719, P = 0.002**
Q8	**r = 0.643, P <**	**r = 0.791, P =**	**r = 0.702, P =**	**r = 0.907, P <**	r = 0.462, P =

	0.001	**0.019**	**0.002**	**0.001**	0.072
Q9	***r* = 502, *P* = 0.002**	*r* = 0.371, *P* = 0.365	***r* = 0.555, *P* = 0.021**	*r* = 0.535, *P* = 0.090	***r* = 0.674, *P* = 0.004**

[a]Bold letter in gray color cell: Significant relationship