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한국 프로야구 투수의 프리시즌 어깨 평가와 Kerlan-Jobe 어깨 팔꿈치 점수에 영향을 끼치는 요소 분석

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Preseason Assessment for Throwing Shoulders in Korean Professional Baseball League Pitchers and Factors Affecting Kerlan-Jobe Orthopaedic Shoulder and Elbow Scores

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Purpose: This study was performed to verify affecting factors to Kerlan-Jobe Orthopaedic Clinic Shoulder and Elbow score (KJOCS) in Korean professional baseball league pitchers at preseason by assessing related variables for throwing.
Methods: Twenty-seven pitchers from the Korean professional baseball league were enrolled in January 2017. The Korean version of KJOCS was administered to each pitcher, and demographics as well as pitching-related indexes such as innings pitched, earned run average in 2016 were collected. Regarding the assessment of the throwing arm, total rotational motion, horizontal adduction, and abduction were measured. Related shoulder physical examinations were also evaluated. The side-to-side difference was evaluated between the throwing and non-throwing arms, and the glenohumeral internal rotation deficit was also calculated. The correlation analyses between KJOCS and variables regarding throwing shoulders as well as demographics and pitching-related indexes were performed.
Results: Regarding the throwing shoulder, the total rotational motion (r=0.45), internal rotation at 90° abduction (r=0.492), and abduction (r=0.446) of the throwing shoulder were positively correlated with the KJOCS (all $p<0.05$). Among demographics, age (r=−0.637) and career (r=−0.549) were negatively correlated with the KJOCS ($p<0.05$). In multiple regression analysis, age was a single associated factor to the KJOCS inversely (r^2=0.466, p=0.001) in Korean professional baseball league pitchers at preseason.
Conclusion: Age was the only affecting factor on KJOCS of pitchers in the Korean professional baseball league and KJOCS could not reflect subtle changes in range of motion and any positive findings of physical examinations in pitchers at preseason.

Keywords: Shoulder, Baseball, Kerlan-Jobe Orthopaedic Clinic Shoulder and Elbow score, Preseason, Correlation

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Introduction

Pitchers in professional baseball leagues are vulnerable overhead athletes who are in a higher possibility of injuring their throwing shoulders and elbows due to repetitive microtrauma which started in their youth and adolescent periods[1,2]. There were numerous literatures describing risk factors of throwing arm injury in pitchers which were loss of glenohumeral internal rotation or other losses of shoulder range of motion (ROM) and rotator cuff muscle weakness as well as stiffness[3-8]. Those changes in the throwing shoulder could lead to changes in pitching mechanics which might cause functional disability of throwing arms in pitchers[9,10]. More specifically, pitchers could suffer from injuries such as labral tears, rotator cuff tears in the shoulder joint as well as ulnar collateral ligament tears, ulnar neuritis, and posteromedial impingement with/without bone spurs or fragments in the elbow joint due to preceding changes of shoulder joint[5,7,11]. Therefore, changes in throwing shoulder in pitchers tend to be recognized more sensitive than those of elbow joint and serial evaluations of throwing shoulder in pitchers should be emphasized as much as controlling pitching counts and pitching mechanics throughout the season.

However, the physical changes in the throwing arm in pitchers could be subtle throughout a season and be difficult to recognized[12]. The preseason medical screening in a professional baseball team should detect those subtle changes to minimize the risk of injury in pitchers during upcoming season. The objective physical examinations by medical personnel in the sports medicine field can be helpful to detect these subtle changes in physical status in pitchers[7,13]; however, the subjective self-assessment tool for throwing arms in pitchers could be more helpful and reliable[14]. To date, there has been limited subjective assessment tool regarding the throwing shoulder in pitchers at preseason and the most well-known subjective questionnaire for evaluation of throwing shoulder in pitchers is Kerlan-Jobe Orthopaedic Clinic Shoulder and Elbow score (KJOCS)[12,15].

The KJOCS has been used to evaluate the functional status of throwing arms in overhead athletes and it was adopted as a formal evaluation tool for shoulder and elbow injury in American Major League Baseball[16]. The Korean version of KJOCS was also developed and validated recently[17]. There were a couple of literatures that administered KJOCS to professional baseball pitchers at preseason and the history of injury in the throwing arm was known to be highly correlated with the lower KJOCS[18,19]. However, we do not know whether this tool has a role for professional baseball league pitchers to reflect the certain physical status of throwing shoulders at preseason. We hypothesized that the KJOCS might be helpful to assess the functional status of throwing shoulders in professional pitchers during preseason, and there might be some correlations between throwing shoulders and KJOCS which might be helpful to detect subtle changes in throwing shoulder. The aim of this study is to verify the affecting factors to KJOCS from assessing throwing shoulders and other factors such as demographics and pitching-related indexes in Korean professional baseball league pitchers at preseason.

Methods

This study was approved by the Institutional Review Board of Bundang Jesaeng Hospital for research ethics and written informed consent exception was approved as a minimal risk study for study subjects (No. DMC 2022-12-003).

1. Study design and population

Forty-three players who were officially registered Korean

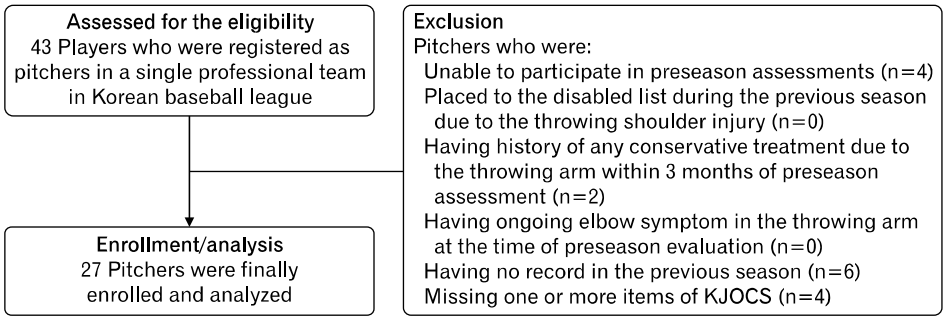

Fig. 1. Exclusion criteria. KJOCS: Kerlan-Jobe Orthopaedic Clinic Shoulder and Elbow score.

professional baseball league as pitchers in a professional baseball team were assessed for eligibility. The exclusion criteria were as followings; pitchers who were unable to participate in the preseason assessment (n=4), pitchers who had been placed on the disabled list during the previous season (2016) due to throwing arm injury (n=0), pitchers who had any conservative treatment to throwing arm within 3 months of preseason assessment (n=2), pitchers who had ongoing elbow symptom in throwing arm at the time of preseason assessment (n=0), pitchers did not have a record in the previous season (n=6) and pitchers missed one or more items of KJOCS (n=4). After the exclusion, a total of 27 pitchers were finally enrolled and analyzed (Fig. 1). We tried

Table 1. Demographics and baseline information regarding pitching-related indexes, physical examinations, and KJOCS in subjects

Variable	Data
No. of subjects	27
Age (yr)	27.1±4.7 (19−37)
Career* (yr)	7.0±5.0 (1−20)
Height (m)	1.85 ±4.75 (1.77−1.93)
Weight (kg)	86.7±7.8 (72.0−100.0)
Body mass index (kg/m^2)	25.4±1.6 (22.2−28.7)
Earned run average	4.9±4.3 (3.6−16.0)
No. of innings pitched in 2016	26.8 ±35.8 (3.3−71.3)
No. of throwing shoulders, right:left	20:7
Total arc of rotation† (°)	
Dominant	170.4±31.9 (115−215)
Non-dominant	175.5± 33.5 (110−225)
External rotation at 90° of abduction (°)	
Dominant	111.1±15.1 (90−135)
Non-dominant	106.9±16.1 (90−140)
Internal rotation at 90°of abduction (°)	
Dominant	60.4±21.5 (15−90)
Non-dominant	67.8±21.9 (20−90)
Horizontal adduction (°)	
Dominant	14.1±6.5 (0−20)
Non-dominant	16.7±5.7 (0−25)
Abduction (°)	
Dominant	135.0±8.6 (110−150)
Non-dominant	140.0±7.4 (120−160)
Hawkins test	
Present	3
Absent	24
O'brien test	
Present	5
Absent	22
Jerk test	
Present	4
Absent	23
Kibler sign	
Present	8
Absent	19
KJOCS	81.4±14.8 (44−100)

Values are presented as mean±standard deviation (range) or number only.
KJOCS: Kerlan-Jobe Orthopaedic Clinic Shoulder and Elbow score (a subjective score system for evaluating for function of overhead athlete's throwing arm, range of score is from 0 to 100, 100 means the best function).
*Career years as professional baseball pitchers. †Sum of external and internal rotations at 90° of abduction.

to follow the concept of previous studies which defined 'healthy pitchers' as being able to participate in their unrestricted competitive role in pitching without problem in season starting at minor league level[16,18]. Every pitcher in the cohort was able to throw a ball, but 6 of 27 pitchers responded that they had pain in shoulder during throwing at the time of assessment.

2. Demographics and the administration of Kerlan-Jobe Orthopaedic Clinic Shoulder and Elbow score

The age (year), height (m), weight (kg), body mass index (kg/m^2), and career (year) as a professional baseball pitcher were identified. The pitching-related indexes such as earned run average (ERA) and innings pitched in the previous season (2016) were collected through the Korean professional baseball league's official website (www.koreabaseball.com). The demographics as well as pitching-related indexes of subjects were summarized in Table 1.

An athletic trainer who was blind to the Korean version of KJOCS[17] administered KJOCS to pitchers before the objective assessment of shoulders by physicians in January 2017. During the completion of questionnaires, pitchers were not interrupted by other pitchers, athletic trainers, and physicians (or raters).

3. Raters and the assessment of shoulder

For every assessment of throwing shoulder in pitchers, two consultants orthopedic as well as sports medicine physicians with career years more than minimal 6 years (rater A, 6 years and rater B, 10 years) were served as raters. They were blind to the results of KJOCS which was administered to each subject just before the physical assessment of the shoulder. At first, rater A performed every measurement of ROM as well as a physical examination of the shoulder, and then rater B repeated the same processes. The measurements were then compared to determine the inter- and intrarater reliability. If there was any disagreement between the two, it was reevaluated to make an agreement and there was no disagreement between the two in the end.

Before shoulder assessment, raters evaluated every elbow of pitchers to minimize the bias caused by elbow problems to KJOCS. In the cohort of the current study, we could not observe any symptomatic elbow or problematic elbow in the throwing arm compared to the non-throwing arm. The diffuse swelling, posteromedial elbow pain, posterior elbow pain during the elbow extension, ulnar tingling sensation, and medial instability with the pain of the throwing elbow were assessed. At first, measurement of ROM of the shoulder was performed, and then physical tests of the shoulder were followed in order.

1) Range of motion

The shoulder's external and internal rotational motions, horizontal adduction and abduction were assessed in a supine position[20,21]. To measure the ROM of the glenohumeral joint by one rater, the anterior pressuring the coracoid process by the other rater to retract and stabilize the scapula to the posterior direction was mandatory[22,23]. The measurements of ROM were obtained by a bubble goniometer and the passive ROMs were recorded. External and internal rotational motions at 90° abduction were measured at the side and the angle was measured between the vertical

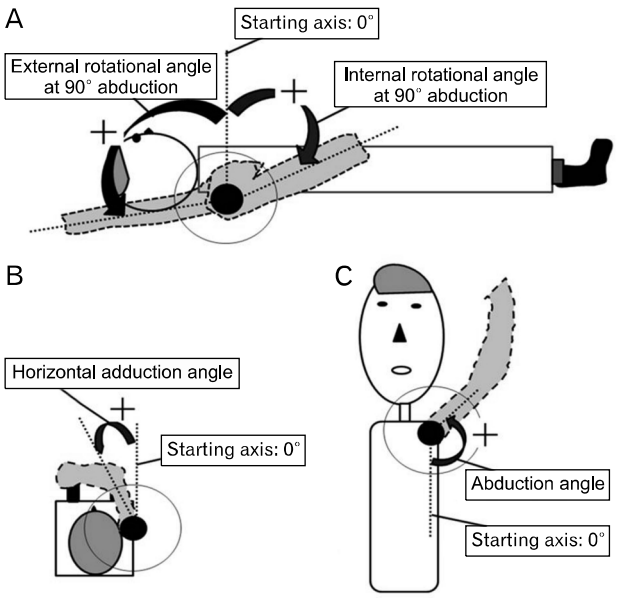

Fig. 2. The measurement of range of motion by a bubble goniometer was drawn in a simplified manner. The measured arm was colored in grey with a dashed outline and axes were meant to be a start or end of measurement and drawn with dotted lines. The angles were depicted with circular black arrows. (A) The subject was positioned in supine and the rotational angle with 90° abduction of the throwing shoulder was measured at side. (B) The subject was positioned in supine and a horizontal adduction angle at 90° abduction of the shoulder was measured between the vertical axis and adducted shoulder axis in the axial plane. (C) The subject was positioned in supine and the abduction angle was measured between the angle of the thorax and the abducted shoulder in the coronal plane.

axis to the bed and arm axis which is maintained with gravity (Fig. 2A)[20,22]. A total rotational motion was defined as the sum of internal and external rotation at 90°abduction of shoulder[24]. The horizontal adduction was measured with 90° abduction of the shoulder with scapula stabilization to the posterior direction in a supine position. The horizontal adduction was defined as the angle between the vertical axis and axis of humerus in the axial plane and the horizontal adduction force is applied to the lateral humerus during measurement (Fig. 2B)[20,22,23]. The abduction was defined as the angle between the axes of the thorax and humerus with the scaption position of the scapula in the coronal plane (Fig. 2C). The side-to-side difference of ROM between throwing and non-throwing shoulder was calculated at each measurement with external and internal rotational motions at 90° abduction, total rotational motion, horizontal adduction and abduction. The glenohumeral internal rotation deficit (GIRD) was defined by following two criteria: (1) more than 8° deficit of total rotational motion (definition 1) or (2) more than 20° deficit of internal rotation in throwing shoulder compared to non-throwing shoulder (definition 2)[25,26].

2) Physical examinations

Pitchers were in an upright position with sitting during the physical examination. The non-throwing shoulder was examined first and the throwing shoulder in the next order. Physical examinations were as followings: Hawkins test for impingement evaluation, Kim test for the evaluation of posteroinferior labral tear[27], and O'Brien active compression test plus bicipital groove tenderness for the evaluation of superior labrum anterior to posterior (SLAP) with biceps lesion. The scapulothoracic dyskinesia was evaluated by observation of the uncoordinated movement of the scapula during forward flexion of arms[28].

4. Statistical analysis

We conducted all statistical analyses using PASW Statistics ver. 18.0 (IBM Corp.). All variables in the current study which were demographics, pitching-related indexes, and findings of shoulder physical examinations were collected and analyzed. For continuous variables, Mann-Whitney U-test was used to compare the difference between the two groups due to the small sample size, and Spearmen correlation analysis was performed. The multiple regression analysis in a stepwise manner was performed with associated factors that were identified as significant in univariate analysis. The statistics were two-tailed, and the p-values of <0.05 were considered statistically significant.

Results

1. Kerlan-Jobe Orthopaedic Clinic Shoulder and Elbow score and throwing shoulder

Regarding the throwing shoulder, total rotational motion, internal rotation at 90° abduction and abduction showed positive correlations with KJOCS with significance (all $p<0.05$), but others such as external rotation at 90° abduction and horizontal adduction did not reveal any correlation (all $p>0.05$) (Table 2). From the side-to-side differences of ROM between throwing and non-throwing shoulders, no significant correlation with KJOCS was observed ($p>0.05$) (Table 3). The incidences of GIRD (n=10, 37% by definition 1 or n=4, 15% by definition 2) were relatively high; however, this did not result in a significant difference in KJOCS (Table 4). Furthermore, the presence of impingement

Table 2. Correlation coefficients (r) between KJOCS and throwing shoulder's ROM

ROM	KJOCS	
	Coefficients (r)	p-value
Total rotational motion (°)	0.450	0.027*
External rotation at 90°abduction (°)	0.257	0.226
Internal rotation at 90° abduction (°)	0.492	0.015*
Horizontal adduction (°)	0.189	0.376
Abduction (°)	0.446	0.049*

KJOCS: Kerlan-Jobe Orthopaedic Clinic Shoulder and Elbow score, ROM: range of motion.
*$p<0.05$, statistically significant.

Table 3. Correlation coefficients (r) between KJOCS and side-to-side differences of ROM between the throwing arm and non-throwing arm

ROM	Side-to-side difference of ROM*	Correlation to KJOCS (r)	p-value
Total rotational motion (°)	−3.7±15.5 (−30 to 30)	0.083	0.700
External rotation at 90° abduction (°)	4.3±11.6 (−10 to 30)	−0.090	0.676
Internal rotation at 90° abduction (°)	−5.9±10.5 (−30 to 20)	0.237	0.265
Horizontal adduction (°)	−2.6±4.7 (−15 to 5)	0.226	0.289
Abduction (°)	−5.0±8.2 (−30 to 0)	0.428	0.060

Values are presented as mean±standard deviation (range).
KJOCS: Kerlan-Jobe Orthopaedic Clinic Shoulder and Elbow score, ROM: range of motion.
*Calculated as ROM of the throwing arm-ROM of non-throwing arm.

Table 4. Comparison of KJOCS regarding the GIRD

GIRD*	KJOCS, mean±SD	p-value
GIRD 1		0.757
Positive (n=10)	81.0±11.8	
Negative (n=17)	81.5±16.2	
GIRD 2		0.935
Positive (n=4)	83.7±5.6	
Negative (n=23)	81.1±15.7	

KJOCS: Kerlan-Jobe Orthopaedic Clinic Shoulder and Elbow score, GIRD: glenohumeral internal rotation deficit, SD: standard deviation.
*In the throwing shoulder compared to the non-throwing shoulder; GIRD 1: >8° deficit of total rotational motion, GIRD 2: >20° deficit of internal rotational motion at 90° abduction.

sign (or Hawkins test positive), SLAP (or O'Brien active compression+bicipital groove tenderness positive), posteroinferior labral tear (or Kim test positive), and scapular dyskinesia have not revealed any difference regarding KJOCS (Table 5).

2. Kerlan-Jobe Orthopaedic Clinic Shoulder and Elbow score and other factors (demographics and pitching-related indexes)

Among the demographics, age (r=−0.637) and career (r=−0.549) were negatively correlated with the KJOCS ($p<0.05$). However, the ERA and innings pitched in the previous year (2016) were not correlated with the KJOCS (Table 6).

3. Multiple regression analysis

From the multiple regression analysis with positive findings in univariate analyses which were total rotational motion, internal rotation at 90° abduction, abduction, age, and career, we found that age was a single associated factor with the KJOCS with inverse manner ($r^2=0.466$, $p=0.001$) (Fig. 3).

Discussion

In the current study, we could say that KJOCS of pitchers at preseason were affected by their age and not by the disease-specific findings such as impingement, labral tear, GIRD, and scapular dyskinesia as well as ROM of their throwing shoulders.

Although the KJOCS is known as a reliable and responsive subjective assessment tool in overhead athletes[16], the correlation between those subtle physical changes of pitchers at a pre-injury level and KJOCS has been questionable. We observed that any positive physical tests did not cause significant changes in KJOCS in pitchers during preseason. There could be several reasons for this as followings. First, the KJOCS itself was designed to represent the functional status of the throwing arm but is not responsible for physical findings of disease such as impingement, posteroinferior labral tear, and scapular dyskinesia although those diseases might affect throwing mechanics to cause injury to disable pitchers at a certain point of time in future. Second, the preseason evaluation was performed at least more than 3 months of full rest throwing arm; therefore, even though there were certain positive findings of disease in the throwing arm, this might not be felt as serious but temporary which could be recovered before the season starts. Third, there were a small number of pitchers with certain diseases in their throwing shoulders: SLAP lesion (5 of 27), impingement syndrome (3 of 27), posteroinferior labral tears (4 of 27), and scapular dyskinesia (8 of 27); and these of low incidence of disease might affect the negative results regarding correlation with KJOCS of the current study. Fourth, the diagnosis based on physical tests in this study could be imperfect to reflect the

Table 5. Comparison of KJOCS

Physical examination	Positivity	KJOCS, mean±SD	p-value
Hawkins	Positive (n=3)	86.0±9.9	0.797
	Negative (n=24)	81.0±15.2	
O'brien+Bc Td*	Positive (n=5)	85.3±7.1	0.830
	Negative (n=22)	80.8±15.6	
Kim	Positive (n=4)	82.0±2.8	0.877
	Negative (n=23)	81.3±15.4	
Scapular dyskinesia	Positive (n=8)	78.5±14.1	0.454
	Negative (n=19)	81.3±15.4	

KJOCS: Kerlan-Jobe Orthopaedic Clinic Shoulder and Elbow score, SD: standard deviation, BC Td: bicipital groove tenderness.
*The positivity refers to positive findings of both tests simultaneously.

Table 6. Correlation coefficients between KJOCS and demographics as well as pitching-related indexes

Index	KJOCS	p-value
Age (yr)	−0.637	0.001*
Career (yr)	−0.549	0.005*
Body mass index (kg/m^2)	−0.044	0.839
Earned run average	−0.291	0.167
Innings pitched in 2016	−0.051	0.813

KJOCS: Kerlan-Jobe Orthopaedic Clinic Shoulder and Elbow score,
*$p<0.05$, statistically significant.

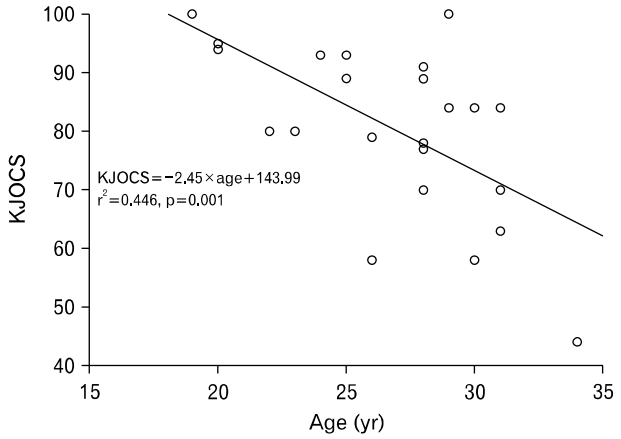

Fig. 3. The correlation between age and Kerlan-Jobe Orthopaedic Clinic Shoulder and Elbow score (KJOCS) showed a linear inverse correlation (r^2=0.466, p=0.001; KJOCS=−2.45×age+143.99) in Korean professional baseball league pitchers at preseason.

functional status of throwing shoulders considering their imperfect diagnostic values[18,28].

In the current study, we observed the amount of total rotational motion, internal rotation at 90° abduction and abduction in throwing shoulders were significantly associated with higher KJOCS in univariate analysis; however, we could not observe any correlation between KJOCS and other ROMs of throwing shoulder as well as any side-to-side difference of ROMs including GIRD. In fact, there have been literatures which have been focused on side-to-side decrease of internal rotational motion such as GIRD as a risk factor for throwing arm injuries in overhead athletes, although it could be thought of as a part of normal adaptive process[3,5,8,11,13,20,25,26]. Some of literatures also reported other side-to-side deficits of ROMs of throwing shoulders such as total rotational motion, external rotational motion, forward flexion, and horizontal adduction as risk factors for throwing arm injuries[7,13,16]. To date, no study has evaluated the effect of change in ROM in throwing shoulder or side-to-side deficit of ROM in throwing shoulder at a pre-injury level on functional performance or subjective functional outcome of throwing shoulder. The deficit of total rotational motion (−3.7°), internal rotation at 90° abduction (−5.9°), horizontal adduction (−2.6°), abduction (−5.0°) as well as gain of external rotation at 90° abduction (4.3°) in throwing shoulder compared to the non-throwing shoulder of the current study were in line with previous studies regarding the trend and amount of side-to-side deficit of ROMs[11,13] and we found that high incidence of GIRD up to 85% from the cohort of this study which we thought to be a sufficient number to prove the non-significant correlation of GIRD with KJOCS. Therefore, the results of the current study regarding the effect of side-to-side deficit of ROM in throwing shoulder on functions of pitchers at preseason could have enough strength to represent any population of baseball pitchers at preseason. However, the positive correlations between

total rotational motion, external rotational motion, abduction in throwing shoulders, and KJOCS observed in the univariate analysis were thought to be an insignificant result that might be affected by a decrease in ROM in aged pitchers, and we found that age was the only factor that affecting the KJOCS with the inverse manner in multivariate regression analysis which we would discuss in next paragraph again. In fact, as an on-site physician, the authors often observed pitchers complaining of their decrease of rotational motion as well as abduction angle of the throwing shoulder which was subtle and undetectable by observers throughout the season, and we thought those subjective feelings of pitchers regarding their throwing shoulder have potential to affect KJOCS although we did not observe any meaningful finding in the current study.

In demographics, age and career were inversely correlated with the KJOCS, but pitching-related indexes such as ERA and innings pitches in the previous year were not correlated with KJOCS in univariate analysis. In multivariate regression analysis, we found that age was the only affecting factor to KJOCS in an inverse manner. This could mean that the functional status of throwing arm in pitchers at preseason reflects the chronologic age not the performance or functions in the previous year. Those findings were contrary to those of Franz et al.[16] which reported that the amount of repetitive throwing seemed to be correlated with KJOCS and the age was not correlated with KJOCS with a cohort of minor league baseball players. Compared to the current study, the difference in results seemed to be coming from the difference in cohorts. The cohort in the study of Franz et al.[16] was mixed players with different field position with age between 23 and 26 years, but the cohort of the current study include only pitchers without any other positional players, and the mean age was 27.1 years (range, 19–37 years) which was older and wider in range compared to the study of Franz et al.[16]. We also believe that pitchers were more affected by age than other positional players due to higher repetition of throwing motion. Gilliam et al.[29] insisted that as the level goes up from high school to professional athletes, the KJOCS tend to be decreased. This could be another supportive evidence for negative impact of age on the function of throwing shoulder in pitchers who were representative of vulnerable overhead athletes. From the known knowledge that the higher KJOCS meant to be the better functional status of the throwing arm in overhead athletes, this study could provide the fact that the aging pitchers were likely to feel the decreasing functional status of the throwing shoulder at preseason, although we could not sure that this was due to physiologic change of aging or psychological distress of aging as athletes.

There were some limitations in this study. First, the number of cohorts was relatively small with overall 27 pitchers, therefore it might be difficult to make a strong conclusion. However, every pitcher involved in this study was able to throw a ball at the time of administration of KJOCS, and the mean KJOCS was 81.4 (range, 44–100) with a wide range of different functional status of throwing shoulders among healthy pitchers. Second, there was a lack of cross-sectional radiologic studies which could support the findings of throwing shoulders in the current study. Third, the result of this study was from the cohort of Korean professional baseball league pitchers. Therefore, another study in different cohorts and large cohorts should be needed to support the results of the current study.

In conclusion, age was the only affecting factor on KJOCS of pitchers in the Korean professional baseball league and KJOCS could not reflect a subtle change of ROM and any positive findings of physical examinations in pitchers at preseason.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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