

## [ Athletic Training ]



# Glenohumeral Range of Motion in Major League Pitchers: Changes Over the Playing Season

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**Background:** Although overhead throwing athletes may develop unique glenohumeral range of motion characteristics, to our knowledge these characteristics have not been studied longitudinally in major league pitchers.

**Hypothesis:** Major league pitchers (starters and relievers) experience an increase in glenohumeral external rotation and a decrease in internal rotation and total range of motion. Glenohumeral internal rotation deficit worsens over a regular playing season.

**Study Design:** Retrospective cohort study.

**Methods:** In 21 major league baseball pitchers (29 individual playing seasons), glenohumeral range of motion was measured in external and internal rotation for the throwing and nonthrowing shoulders before and at the conclusion of the regular season. The total range of motion (the sum of external rotation and internal rotation) and the glenohumeral internal rotation deficit were calculated (the difference between internal rotation of the nonthrowing shoulder minus that of the throwing shoulder), and data were compared between starting and relief pitchers.

**Results:** The overall mean changes in external rotation (+1.5°), internal rotation (+2.7°), and total range of motion (+3.3°) were not statistically significant. However, starting pitchers showed statistically significant increases in internal rotation (+6.5°,  $P = 0.01$ ) and total range of motion (+7.9°,  $P = 0.04$ ), whereas relief pitchers had significant worsening of glenohumeral internal rotation deficit (+5.3°,  $P = 0.04$ ).

**Conclusions:** The characteristics of glenohumeral range of motion in major league pitchers did not differ significantly from the beginning to the end of a season, but significant changes did occur between starting and relief pitchers.

**Clinical Relevance:** Adaptations to the daily routines of starter and reliever pitchers may be warranted on the basis of these findings.

**Keywords:** baseball; pitching; glenohumeral range of motion; shoulder

Overhead throwing athletes develop unique glenohumeral range of motion (ROM) characteristics.<sup>11</sup> Studies have consistently reported more external rotation (ER) and less internal rotation (IR) at 90° of abduction in the throwing versus nonthrowing shoulders of baseball players.<sup>8-10,14,16-19,21-24</sup> Most of those studies<sup>9</sup> were descriptive in methodology and recorded one set of measurements, obtained before the regular playing season.

It is important to measure glenohumeral ROM in the pitcher to help identify posterior capsular tightness, which has been linked to shoulder pain and injury.<sup>18,23,25</sup> Furthermore, several authors have postulated that posterior capsular tightness alters glenohumeral kinematics, leading to possible pathologic changes, such as internal impingement and superior labrum anterior posterior (SLAP) tears.<sup>6,11,12,18,25,26</sup> Although posterior capsular tightness has associations with possible abnormal changes, the culprit responsible for glenohumeral IR deficit (GIRD) has not definitively been determined. Posterior capsular tightness, increased humeral

\*References 2-4, 5, 8-10, 14, 16-19, 21-24, 28

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retroversion,<sup>29</sup> or a combination could be responsible for the finding.

The literature on glenohumeral ROM in baseball players has focused mostly on collegiate<sup>14,18,19,21,23</sup> and professional players.<sup>2-4,5,8-10,16,22,24</sup> Most studies of professional players have concentrated on pitchers, but some<sup>2,5,9,24</sup> have included data on position players. Most of those studies<sup>8</sup> reported on baseball players' glenohumeral ROM at one moment in time, usually before the season. Despite extensive research on the glenohumeral ROM of baseball players, there is limited information on major league players. To our knowledge, only 1 study has reported exclusively on major league pitchers.<sup>5</sup> In addition, no data on starting versus relief pitchers have been reported.

This pilot study was a retrospective review of data collected in a prospective manner. The goal of our study was to examine glenohumeral ROM changes over the course of a season among major league pitchers and compare the characteristics of such changes between starters and relievers. Specifically, the aims were to evaluate the glenohumeral ROM in major league pitchers at 90° of abduction over the course of a season, evaluate GIRD over the course of a season, and differentiate the data in terms of starting and relief pitchers. We hypothesized that major league pitchers would have an increase in glenohumeral ER, a decrease in IR and total ROM, and a worsening GIRD over the course of the season.

## MATERIALS AND METHODS

This study was approved by the institutional review board of John Hopkins Medicine.

### Study Population

The population for this retrospective cohort study comprised one Major League Baseball team, the Baltimore Orioles. Data were collected as part of the routine pitcher's assessment. Inclusion criteria were team position of pitcher, measurements while the pitcher was on the active 25-man major league roster, and measurements before and after the season. Exclusion criterion was surgery on the shoulder or elbow within 12 months of any measurements obtained.

From February 2004 through October 2007, 21 pitchers met the inclusion criteria (average age, 29.0 ± 4.1 years; average height, 188 ± 0.79 cm; average weight, 90.7 ± 7.94 kg). These pitchers represented 29 individual seasons: 1 season, 16 pitchers; 2 seasons, 2 pitchers; and 3 seasons, 3 pitchers. For the pitchers with multiple seasons, the data were analyzed on the same per-season basis as that for pitchers with 1 season. In addition, 10 pitchers who had performed as both starters and relievers during a given season were assigned to the group that represented their primary role for that season. Five starters had 7 or fewer relief appearances and were therefore classified as starting pitchers, whereas 3 relievers started 2 or

fewer games each and were classified as relief pitchers. Two starters who had 14 and 20 relief appearances with 23 and 17 starts, respectively, and more than 100 innings were classified as starting pitchers because this number of starts and innings pitched was considered more than what a reliever would normally perform. Based on 29 seasons, 14 pitchers (48%) were classified as starters and 15 (52%) as relievers; 16 (55%) were right-hand dominant.

The demographics of the 2 groups were compared in terms of age, height, and weight to determine if the differences between their baseball statistics would be those expected as a result of their pitching roles.

### Testing Procedure

The 2 certified athletic trainers for the team (B.G.E., R.L.B.) performed all measurements and collected all data. These trainers collectively have greater than 55 years of professional baseball experience and have been measuring glenohumeral ROM with the same technique since 2001.

Measurements were made during the first 2 weeks of spring training before formal exhibition games and during the final home stand of the regular season before any throwing on that day. All measurements were obtained by the same 2 examiners, using the same technique every year at the start and end of the season. On the day of measurement, each pitcher was positioned supine on a standard treatment table before beginning his stretching or throwing routines (Figure 1). The scapula was stabilized by a posteriorly directed force to the anterior shoulder. To gauge the limits of passive internal and external ROM, the examiner used endpoint feel and visualization to monitor the point at which the shoulder began to lift off the table. The examiners applied no overpressure. A standard long-arm goniometer (Medco Supply Company, Inc, Tonawanda, New York) with attached customized bubble inclinometer was used to measure bilateral IR and ER at 90° of abduction with the elbow flexed. Total ROM and GIRD (dominant-arm IR subtracted from nondominant-arm IR) were calculated from these data. The reference point for measurement was the axis of the goniometer over the olecranon, with one arm of the goniometer along the ulnar shaft and the other arm of the goniometer perpendicular to the floor, as confirmed by the custom bubble inclinometer attachment.

### Data Analysis

Data analysis was performed by a statistician (K.R.A.) using Stata statistical software (version 10.0, Stata Corp, College Station, Texas). The main goal of the analysis was to examine the glenohumeral ER, IR, total ROM, and GIRD of major league pitchers—as an overall group, as starters, and as relievers—over the course of a regular playing season.

A paired student *t* test was used to analyze the start- and end-of-season glenohumeral ROM data for all pitchers. Descriptive statistics and boxplots were used to summarize and describe the dominant- and nondominant-arm glenohumeral

\*References 2-4, 5, 8-10, 14, 16, 18, 19, 21-24

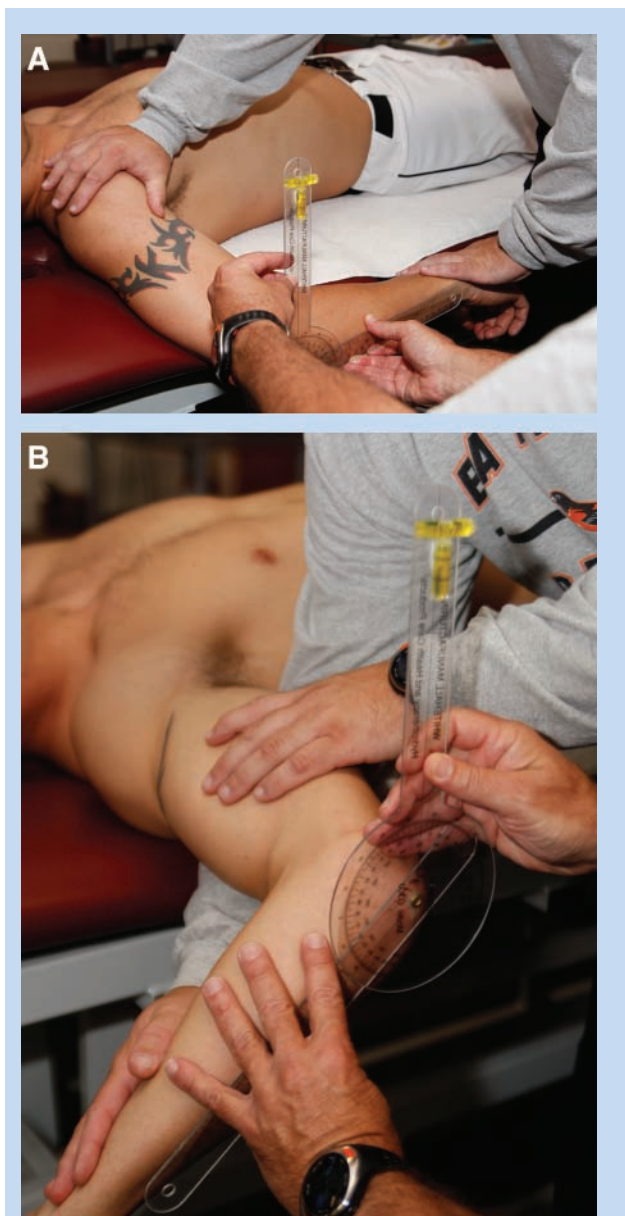


Figure 1. Before the pitcher began his stretching or throwing routine on the day of measurement, he was positioned supine on a standard treatment table. The scapula was stabilized by a posteriorly directed force to the anterior shoulder, and a standard long-arm goniometer with attached customized bubble inclinometer was used to measure external rotation (A) and internal rotation (B) at 90° of abduction with the elbow flexed.

ER, IR, total ROM, and GIRD at the start and end of the season for all participants. Age, height, weight, and baseball statistics were summarized separately for starting and relief pitchers and compared by type of pitcher with analysis of variance. Exploratory methods, including tests for normality, linearity, the presence of outliers, and contingency tables, were used to assess the nature of the data.

The characteristics of dominant-arm glenohumeral ER, IR, total ROM, and GIRD over time were explored with scatter, line, and residual regression plots. The autocorrelation function and a scatter-plot matrix determined the correlation structure of the data. Bivariate relationships between variables (pitcher age and baseball statistics) and outcome measures were explored with longitudinal exploratory linear regression methods. Independent variables with  $P \leq 0.15$  or those considered relevant from a theoretical perspective were entered into multiple-variable linear mixed-effects regression models. The 0.15 level was used as a screening criterion to allow for the possibility that a collection of variables—each of which may be weakly associated with the outcome—may become important predictors when placed in a model together.<sup>13</sup> A random effect was included to account for the correlation between each pitcher's start- and end-of-season measurement. Multiple-variable linear regression analyses were conducted for all pitchers and for starting and relief pitchers separately. Statistical significance was set at  $P < 0.05$ .

## RESULTS

### All Pitchers

As expected, the pitchers showed glenohumeral characteristics consistent with results reported by numerous other studies,<sup>\*\*</sup> such as significant differences between the throwing and nonthrowing shoulders in ER and IR at the start and end of the playing season, with a general retention in overall ROM (Table 1). Overall, these major league pitchers showed little variability with regard to ER, IR, ROM, and GIRD, based on the measurements before and at the end of the season. No statistically significant differences were observed for any of these variables (Table 2).

### Starting Versus Relief Pitchers

Analysis of variance between starters and relievers (Table 3) determined a statistically significant difference in games,  $F = 37.4$ ,  $P < 0.01$ , and games started,  $F = 180.0$ ,  $P < 0.01$ . In addition, there was a statistically significant difference between starters and relievers in the number of innings pitched: 167.6 and 64.7, respectively,  $F = 66.6$ ,  $P < 0.01$ . Multiple-variable analysis showed that starting pitchers had significant gains in IR (6.5°; 95% confidence interval [CI] = 1.3, 11.8;  $P = 0.01$ ) and total ROM (7.9°; 95% CI = 0.37, 15.4;  $P = 0.04$ ) (Table 4). Relief pitchers had a mean increase in GIRD of 5.3°, which was statistically significant (95% CI = 0.28, 10.3;  $P = 0.04$ ) after multiple-variable analysis (Table 5).

## DISCUSSION

The most common injuries in Major League Baseball players involve the shoulder.<sup>7</sup> Pitchers compose almost half of all

\*\*References 2-4, 5, 8-10, 14, 16-19, 21-24, 28

Table 1. Major league pitchers: Dominant versus nondominant shoulder at start and end of the season.<sup>a</sup>

	Dominant Shoulder (°)	Nondominant Shoulder (°)	Mean Difference (95% CI)	P
Start of season				
External rotation	124.8 ± 19.5	116.3 ± 12.7	8.5 (2.0, 15.0)	0.01
Internal rotation	70.9 ± 11.8	76.3 ± 12.4	-5.4 (-10.8, -0.06)	0.05
Total range of motion	196.5 ± 22.1	193.6 ± 19.9	2.9 (-1.7, 7.6)	0.20
End of season				
External rotation	126.3 ± 21.6	119.0 ± 16.4	7.3 (1.5, 13.0)	0.01
Internal rotation	73.6 ± 13.2	81.4 ± 10.4	-7.9 (-12.7, -3.0)	0.01
Total range of motion	199.9 ± 26.0	200.4 ± 22.0	-0.6 (-5.9, 4.8)	0.80

<sup>a</sup>n, 29 seasons (some of the 21 pitchers had multiple seasons). CI, confidence interval.

Table 2. Linear regression models of the effect of time in the throwing shoulders of major league pitchers.<sup>a</sup>

	Start of Season (°)	End of Season (°)	Mean Difference (95% CI)	P
External rotation	124.8 ± 19.5	126.3 ± 21.6	1.5 (-3.1, 6.1)	0.53
Internal rotation	70.9 ± 11.8	73.6 ± 13.2	2.7 (-1.5, 6.9)	0.20
Total range of motion	196.5 ± 22.1	199.9 ± 26.0	3.3 (-3.1, 9.8)	0.31
GIRD <sup>b</sup>	5.4 ± 14.2	7.9 ± 12.8	2.4 (-2.1, 7.0)	0.30

<sup>a</sup>All analyses were adjusted for age (years) and type of pitcher (starter or reliever). n, 29 seasons (some of the 21 pitchers had multiple seasons). CI, confidence interval.

<sup>b</sup>GIRD, glenohumeral internal rotation deficit—defined as internal rotation in the nonthrowing shoulder minus the internal rotation in the throwing shoulder.

players on major league disabled lists and account for 57% of total disabled-list days.<sup>7</sup> GIRD is a major concern to throwing athletes because of its known association with injury.<sup>11,12,18,21,25,28</sup> The present hypothesis was based on literature<sup>8-10,14,16-19,21-24</sup> showing unique glenohumeral ROM in the throwing shoulder—namely, increased ER and decreased IR at 90° of abduction. In addition, fatigue and wear over the season likely result in a decrease in IR that is clinically more significant than gains in ER, ultimately decreasing the total ROM; furthermore, GIRD would likely worsen secondary to the additional IR loss. The present hypothesis also developed from the concerns that GIRD was a progressive problem and that some pitchers would gradually lose IR over the course of the season.

Contrary to the hypotheses, the study cohort showed no statistically significant changes in ROM over the course of

a full season. Significant differences were found when the starting and relief pitcher subgroups were closely examined. In fact, starting pitchers showed significantly improved IR and total ROM, whereas relief pitchers experienced significant GIRD worsening. The reasons for these differences are open to speculation. Starters typically have the benefit of a 5-day pitching rotation. This structured schedule allows for a predictable routine, with a period of relative rest, regular stretching, and scheduled bullpen pitching. The starting pitchers on this major league team undergo formal posterior capsule stretching the day of their start and the day of their bullpen assignment (usually day 2 or 3 of the rotation cycle). The stretching protocol is likely better and more consistent in comparison with that in the minor leagues because of a structured schedule, the players' maturity, and the trainers'

**Table 3. Demographics and statistics for starting and relief pitchers.<sup>a</sup>**

	Starters n, 15	Relievers n, 14
Age, years	27.6 ± 2.6	30.8 ± 4.6
Height, cm	188 ± 0.64	191 ± 1.97
Weight, kg	91.0 ± 9.0	90.6 ± 6.9
Baseball statistics		
No. season games played	30.7 ± 6.1	61.0 ± 18.4*
Season games started	27.3 ± 6.3	0.36 ± 0.74*
Season innings pitched	167.6 ± 40.3	64.7 ± 12.8*
No. career games	105.5 ± 68.6	335 ± 228.3
Career games started	89.8 ± 63.6	9.8 ± 25.8
Career innings pitched	546.0 ± 383.6	361.5 ± 259.5
Major league baseball experience, years	3.6 ± 2.0	5.9 ± 3.4

<sup>a</sup>n, 29 seasons (some of the 21 pitchers had multiple seasons).

\**P* < .001 (statistically significant difference between starters and relievers).

experience. For these reasons and because of a set rotation, the potential benefits may be realized more by starting pitchers than relievers. Relief pitchers on this major league team routinely undergo posterior capsular stretching on a daily basis. The observed improvements seen in the motion of starting pitchers in comparison with that of the relievers suggest that stretching alone is not solely responsible for prevention of glenohumeral motion changes. Relief pitchers, because of the nature of their role, appear in more games and may throw in games on consecutive days. In addition, they are often brought into a game with little preparation, or they may warm up one or more times without actually entering the game.

This study appears to be the first to show changes in the throwing shoulder of professional pitchers over the course of the season. Debate still exists as to the cause of GIRD. Soft tissue changes, humeral torsion, or a combination of these could be responsible. Crockett et al<sup>8</sup> found significantly increased humeral head retroversion, glenoid retroversion, and

ER in the throwing shoulder compared with the nonthrowing shoulder. They also found that IR was significantly less in the throwing shoulder than in the nonthrowing shoulder. No significant differences were found between shoulders for total ROM, anterior or posterior glenohumeral laxity, or the sulcus sign. The researchers concluded that the loss of IR is the result of an adaptive osseous change. Osbahr et al<sup>19</sup> found that greater retroversion of the humerus is associated with an increased ER. They concluded that glenohumeral ROM characteristics in the throwing shoulder are a result of not only soft tissue adaptation but also osseous adaptation. Reagan et al<sup>21</sup> reported that the loss of IR and the gains in ER may be related more to proximal humeral adaptive changes than to changes in the soft tissues. Note, however, that these 3 studies provided data on only 1 measurement and did not evaluate changes over time.

Yamamoto et al<sup>29</sup> concluded that the repetitive throwing motion does not worsen humeral retroversion but rather restricts the physiologic derotation process of the humeral head during growth. Levine et al<sup>15</sup> focused on the rapid growth that takes place at the proximal humeral physis from age 13 to 16 years; this finding is consistent with their results of increased ER and decreased IR in individuals older than 12 years. In the current study, the participants were pitchers aged 29.0 ± 4.1 years who had reached the highest level of their profession. It was logical to presume that they possessed an increased humeral retroversion because they had likely been throwing high volumes since childhood; therefore, they had probably not experienced any additional bony changes. Any changes observed over the season would most likely be secondary to soft tissue alterations.

Other studies have attributed changes in ROM to soft tissue alterations as well. Lintner et al<sup>16</sup> showed that a stretching program can result in measurable changes in ROM. Significant differences were noted with pitchers in a minimum 3-year stretching program designed to maintain and improve IR, compared with a control group. Reinold et al<sup>22</sup> measured ROM in professional pitchers before, immediately after, and 24 hours after a 50- to 60-pitch bullpen session. They found significant changes in IR (-9.5° and -7.6°) and total ROM (-10.7° and -7.7°) over that 24-hour period. They concluded that the ROM changes resulted from acute musculoskeletal adaptations. Eccentric muscle contraction during the follow-through phase of pitching has been shown to result in increased passive muscular tension and loss of joint ROM.<sup>20</sup> Starters may be differently affected by the soft tissue musculotendinous changes, as compared to relievers, at least in part because of differences in pitching frequency, number of pitches, and time interval between appearances. In a population of relievers, it is difficult to calculate and decipher such differences because of the different roles the relievers play: long relievers, setup men, closers, and even left-handed specialty pitchers. Relievers may possess a more adaptive posterior capsule than starters.

A cause-and-effect relationship between GIRD and shoulder injury has not been proven, although several mechanisms

Table 4. Linear regression models of the effect of time on throwing shoulders of starting pitchers.<sup>a</sup>

	Start of Season (°)	End of Season (°)	Mean Difference (95% CI)	P
External rotation	126.1 ± 18.3	129.1 ± 22.2	3.0 (-3.9, 9.9)	0.40
Internal rotation	67.1 ± 12.2	73.7 ± 10.2	6.5 (1.3, 11.8)	0.01
Total range of motion	194.9 ± 23.7	202.7 ± 23.3	7.9 (0.37, 15.4)	0.04
GIRD <sup>b</sup>	7.4 ± 16.9	7.1 ± 12.4	-0.27 (-7.4, 6.9)	0.94

<sup>a</sup>All analyses were adjusted for age (in years). n, 15 seasons. CI, confidence interval.

<sup>b</sup>GIRD, glenohumeral internal rotation deficit—defined as internal rotation in the nonthrowing shoulder minus the internal rotation in the throwing shoulder.

Table 5. Linear regression models of the effect of time on throwing shoulders of relief pitchers.<sup>a</sup>

	Start of Season (°)	End of Season (°)	Mean Difference (95% CI)	P
External rotation	123.4 ± 21.9	123.3 ± 21.3	-0.1 (-5.9, 5.7)	0.96
Internal rotation	74.9 ± 10.2	73.5 ± 16.2	-1.4 (-7.3, 4.6)	0.66
Total range of motion	198.3 ± 21.1	196.8 ± 29.2	-1.5 (-11.5, 8.5)	0.77
GIRD <sup>b</sup>	3.4 ± 10.7	8.6 ± 13.6	5.3 (0.28, 10.3)	0.04

<sup>a</sup>All analyses adjusted for age (years). n = 14 seasons. CI, confidence interval.

<sup>b</sup>GIRD, glenohumeral internal rotation deficit—defined as internal rotation in the nonthrowing shoulder minus the internal rotation in the throwing shoulder.

have been postulated.<sup>1,6,11,12,18,25,26</sup> The current study did not intend to correlate glenohumeral motion with injury but to observe the changes that took place in the throwing shoulder during a season. Burkhart et al<sup>6</sup> suggested that loss of IR with increasing GIRD makes a pitcher susceptible to a “peel-back” phenomenon, leading to SLAP lesions. Andrews et al<sup>1</sup> suggested that a SLAP lesion resulted from tensile load on the long head of the biceps, tearing the superior labrum off the glenoid during the deceleration phase. There is no consensus regarding what amount of GIRD is the threshold for increasing the risk of injury. Burkhart et al reported that the 124 baseball pitchers whom they treated arthroscopically for a symptomatic type 2 SLAP lesion had a measured GIRD greater than 25° (average, 53.0°). In the current study, 3 pitchers (all starters) began the season with a GIRD greater than 25°, and 3 (1 starter and 2 relievers) ended the season with a GIRD greater than 25°; none of these pitchers had injuries. The use of GIRD as a measure of injury risk should be questioned. By definition, GIRD (nonthrowing-shoulder IR minus throwing-shoulder IR) is a measurement of one moment in time. Although GIRD at the start of a season could be high and viewed as a risk for injury, a pitcher’s IR could actually improve over the season. In this

scenario, if the pitcher gains IR in the nonthrowing shoulder secondary to stretching, his GIRD could worsen even though he has improved IR in the throwing shoulder. In the current study, the starting pitcher’s average nonthrowing-shoulder IR improved over the season (6.3°); the throwing-shoulder IR also improved (6.5°). The GIRD did not change (< 1°), because of the improvement in the IR of the nonthrowing arm. The relievers had a significant worsening of GIRD (5.3°) (Table 5) with a mean loss of 1.4° of IR in the throwing arm over the season. Although only 1.4° was lost over the season, the significant finding of GIRD worsening is a result of the improvement of the IR in the nonthrowing shoulder. This finding suggests that worsening of GIRD could be the result of developments in the nonthrowing shoulder. It is also plausible that relievers do not adapt over the season as well as do starters.

One limitation of the current study is that no reliability or formal interobserver or intraobserver error analysis was performed. However, the fact that all measurements were made by the same 2 experienced certified athletic trainers for the entire study period at the start and end of each season was a strength. In addition, they used a bubble inclinometer attached to the goniometer and stabilized the scapula by a posteriorly directed

force over the anterior shoulder so that only glenohumeral motion was measured. Reinold et al<sup>22</sup> performed a test-retest reliability analysis in which intraclass correlation coefficients were calculated; single-measure intraclass correlation coefficient results were .8740 for ER and .8115 for IR. Of note, they used a technique of endpoint feel and visualization of the scapula as it began to move off the table to avoid altering the normal glenohumeral arthrokinematics during measurement. Wilk et al<sup>28</sup> reported the assessment and reliability of 3 techniques for measuring passive glenohumeral ROM: no stabilization, anterior stabilization of the humeral head, and scapular stabilization. They found that their scapular stabilization technique had the highest intrarater intraclass coefficients reproducibility (.62 with scapular stabilization versus .50 with anterior stabilization of the humeral head). With this technique, the clinician stabilizes the scapula by grasping the coracoid process and the spine of the scapula posteriorly. Interrater intraclass coefficients reproducibility was .45 with anterior stabilization of the humeral head versus .43 with scapular stabilization of the coracoid and posterior scapular spine. The amount of variability in IR measurements has been noted: IR values as high<sup>5</sup> as 83° and up to 62° in professional pitchers.<sup>27</sup>

Brown et al<sup>5</sup> did not perform the measurements in the supine position but reported the highest IR of all major league players. In the current study, throwing shoulder IR was generally higher than that previously reported (70.9° preseason and 73.6° postseason).<sup>3,4,8-10,18,21-23</sup> In addition, the current study population was exclusively major league pitchers. Borsa et al<sup>4</sup> reported IR values close to these (68.6°), but overpressure was used with the passive ROM and measured after the scapula began to move. The purpose of the current study was not to report the whole glenohumeral ROM value but the difference in the values at 2 time points—that is, the change rather than a single value.

An additional limitation of the current study was the small population size (21 pitchers, 29 seasons), although it does represent a pure series of only major league pitchers. A major league pitching staff is usually composed of 11 pitchers, thus limiting our potential participants. The current study differed from previous reports by measuring glenohumeral ROM over the course of a major league season. By studying only major league players, many variables were removed.

Without a control group, it is difficult to determine the influence of the stretching program on the results. There were differences in the stretching protocols between starters and relievers; both groups routinely performed the stretches, with starters on a more regulated daily protocol secondary to their set rotation.

A power analysis was not performed because the study was retrospective and the inclusion criteria would have limited the number of pitchers.

## CONCLUSION

The major league pitchers showed minimal changes in ER, IR, total ROM, and GIRD during the season. Starting pitchers had significant gains in IR and total ROM. Relief pitchers had a significant increase in GIRD. These results suggest that the ROM

characteristics of the shoulder differ between starting and relief pitchers. The differences in the roles of starters and relievers may make relievers more vulnerable to GIRD and, possibly, to injury.

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