Changes in Shoulder and Elbow Passive Range of Motion After Pitching in Professional Baseball Players

Michael M. Reinold,*†‡ PT, DPT, ATC, CSCS, Kevin E. Wilk,§¶ PT, DPT, Leonard C. Macrina,§ MSPT, CSCS, Chris Sheheane,§ ATC, Shouchen Dun,ll MS, Glenn S. Fleisig,‖ PhD, Ken Crenshaw,‖‖ ATC, CSCS, and James R. Andrews,‖‖‖ MD

From the 1Boston Red Sox Baseball Club, Boston, Massachusetts, 2Massachusetts General Hospital, Department of Orthopedics, Sports Medicine Division, Boston, Massachusetts, 3Champion Sports Medicine, Birmingham, Alabama, 4American Sports Medicine Institute, Birmingham, Alabama, 5Arizona Diamondbacks Baseball Club, Phoenix, Arizona, and 6Alabama Sports Medicine and Orthopedic Center, Birmingham, Alabama

Background: The overhead throwing athlete has unique range of motion characteristics of the shoulder and elbow. Numerous theories exist to explain these characteristics; however, the precise cause is not known. Although it is accepted that range of motion is altered, the acute effect of baseball pitching on shoulder and elbow range of motion has not been established.

Hypothesis: There will be a reduction in passive range of motion immediately after baseball pitching.

Study Design: Controlled laboratory study.

Methods: Sixty-seven asymptomatic male professional baseball pitchers participated in the study. Passive range of motion measurements were recorded using a customized bubble goniometer for shoulder external rotation, shoulder internal rotation, total shoulder rotational motion, elbow flexion, and elbow extension on the dominant and nondominant arms. Testing was performed on the first day of spring training. Measurements were taken before, immediately after, and 24 hours after pitching.

Results: A significant decrease in shoulder internal rotation (–9.5°), total motion (–10.7°), and elbow extension (–3.2°) occurred immediately after baseball pitching in the dominant shoulder (P < .001). These changes continued to exist 24 hours after pitching. No differences were noted on the nondominant side.

Conclusion: Passive range of motion is significantly decreased immediately after baseball pitching. This decrease in range of motion continues to be present 24 hours after throwing. High levels of eccentric muscle activity have previously been observed in the shoulder external rotators and elbow flexors during pitching. These eccentric muscle contractions may contribute to acute musculotendinous adaptations and altered range of motion. The results of this study may suggest a newly defined mechanism to range of motion adaptations in the overhead throwing athlete resulting from acute musculoskeletal adaptations, in addition to potential osseous and capsular adaptations.

Keywords: overhead throwing athlete; glenohumeral joint; capsule; internal impingement
These ROM characteristics have been shown by several authors in studies of baseball and tennis players. Although the altered ROM observed is currently accepted as a physiological adaptation that occurs normally in overhead throwing athletes, no study to date has documented the acute effect of baseball pitching on ROM. Alterations in ROM as the result of baseball pitching may have implications for injury potential. Furthermore, understanding the acute effect of pitching on ROM may assist in the evaluation of the injured players and the design of injury prevention stretching programs. Thus, the purpose of the present study was to examine the acute effects of baseball pitching on ROM of the shoulder and elbow in professional athletes.

METHODS

Subjects

Sixty-seven professional baseball pitchers participated in the study (mean age, 26 ± 4 years; height, 171 ± 5 cm; weight, 92 ± 10 kg). Fifty-one were right-hand dominant, and 16 were left-hand dominant. All subjects were asymptomatic of shoulder and elbow pain and demonstrated no signs of injury at the time of testing. Subjects were excluded if they had undergone a previous surgery of the shoulder or elbow within the last 12 months before data collection. All measurements were taken during the first 2 days of spring training, before the beginning of practice sessions or the season. The subjects were advised of the nature of the procedure, and informed consent was obtained before testing.

Testing Procedure

Measurements of bilateral passive shoulder ER and IR at 90° of abduction and 10° of horizontal adduction along with elbow flexion and extension were assessed (Figures 1-4). The order of extremity and measurement performed was randomized before data collection. Two examiners were consistently used for all measurements, 1 to position the extremity (M.M.R.) and 1 to align and read the goniometer (C. S.). Subjects were positioned in the supine position with a towel roll placed between the arm and the table. The examiner positioning the extremity was blinded to the results of the measurement.

The examiner passively moved the extremity to the end ROM, and the position was held as the goniometer was aligned and read. The ER and IR were performed with the table stabilizing the scapula. For shoulder ER, elbow flexion, and elbow extension, the motion was stopped at the subject’s end of available ROM when full capsular or bony end feel was achieved. For shoulder IR, a combination of end feel and visualization of compensatory movement was used to determine the end of ROM. The extremity was moved until the shoulder was visualized to begin lifting off the table; motion was stopped when this movement occurred. The humeral head was not manually stabilized to avoid altering the normal glenohumeral arthrokinematics during measurement.

A standard goniometer with an attached customized bubble inclinometer was used to ensure proper perpendicular alignment of the goniometer. For shoulder measurement, the fulcrum of the goniometer was positioned over the olecranon process, with one arm of the device perpendicular to the ground and the other arm aligned along the ulnar to the ulnar styloid process. For elbow measurements, the fulcrum of the goniometer was positioned over the lateral epicondyle of the humerus, with one arm of the device along the length of the humerus to the tip of the acromion process and the other arm along the length of the radius to the radial
Positive elbow extension was defined as motion past 0° into hyperextension. Conversely, negative elbow extension was defined as motion before 0°, such as with an elbow flexion contracture.

Measurements were initially taken before any warm-up, exercise, or throwing program was performed. Subjects then warmed up with jogging for 5 minutes, generalized full-body stretching for 15 minutes, and a long-toss program up to 27.4 m for 10 minutes. Subjects then began pitching from a standard pitching mound for 50 to 60 pitches at full intensity. All ROM measurements were repeated within 30 minutes of the conclusion of pitching. All measurements were repeated again on the dominant side using the same procedures 1 day (24 hours) after initial testing before the subject performed any warm-up exercises or throwing.

Reliability

A pilot study was performed before data collection to assess the test-retest intratester reliability of the goniometric methodology of this study. Ten asymptomatic male subjects (mean age, 28.3 years; height, 180 cm; weight, 88 kg) were measured once in all 4 positions by the same examiners used in the main study. All 4 measurements were randomly repeated on 5 consecutive days to assess test-retest intratester reliability. The order of tests performed was randomized. All subjects refrained from participating in any overhead throwing sports during the testing period.

To examine the rest-retest reliability, intraclass correlation coefficients (ICC3,1) were calculated on shoulder ER, shoulder IR, elbow flexion, and elbow extension using data collected in the pilot study. Single-measure intraclass correlation results were 0.8115 for shoulder IR, 0.8740 for shoulder ER, 0.9053 for elbow flexion, and 0.9740 for elbow extension.

Data Analysis

For the dominant side, a 1-way repeated-measures analysis of variance was performed for each of the 4 variables to evaluate the differences in ROM before, immediately after, and 24 hours after throwing. When a statistical significance was detected, post hoc paired t tests were conducted to test for significance of pairwise comparisons. For the nondominant side, a paired-samples t test was performed for each of the 4 variables to evaluate the difference of ROM before and after pitching. A significance level of P < .01 was adopted to control for type I error. All statistical analyses were performed using SPSS 10.0 (SPSS Science Inc, Chicago, Ill).

### Table 1

<table>
<thead>
<tr>
<th>Range of Motion Before, After, and 24 Hours After Pitching in the Dominant Arm&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Before</th>
<th>After</th>
<th>24 Hours After</th>
<th>P for ANOVA</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Shoulder</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ER</td>
<td>136.5 ± 9.8</td>
<td>135.3 ± 9.3</td>
<td>136.5 ± 9.0</td>
<td>.213</td>
</tr>
<tr>
<td>IR</td>
<td>54.1 ± 11.4</td>
<td>44.6 ± 11.9&lt;sup&gt;b&lt;/sup&gt;</td>
<td>46.5 ± 10.0&lt;sup&gt;b&lt;/sup&gt;</td>
<td>&lt;.001&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>TM</td>
<td>190.6 ± 14.6</td>
<td>179.9 ± 13.7&lt;sup&gt;b&lt;/sup&gt;</td>
<td>182.9 ± 11.5&lt;sup&gt;b&lt;/sup&gt;</td>
<td>&lt;.001&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>Elbow</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flexion</td>
<td>144.9 ± 7.1</td>
<td>144.7 ± 5.9</td>
<td>145.8 ± 5.8</td>
<td>.264</td>
</tr>
<tr>
<td>Extension</td>
<td>−5.1 ± 9.5</td>
<td>−8.3 ± 8.8&lt;sup&gt;b&lt;/sup&gt;</td>
<td>−7.7 ± 8.9&lt;sup&gt;b&lt;/sup&gt;</td>
<td>&lt;.001&lt;sup&gt;b&lt;/sup&gt;</td>
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</tbody>
</table>

<sup>a</sup>Data are mean degrees ± SD. ANOVA, analysis of variance; ER, external rotation; IR, internal rotation; TM, total motion.

<sup>b</sup>Significantly different than before throwing (P < .01).

### Table 2

<table>
<thead>
<tr>
<th>Range of Motion Before and After Pitching in the Nondominant Arm&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Before</th>
<th>After</th>
<th>P for Paired-Samples t Test</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Shoulder</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ER</td>
<td>124.2 ± 9.1</td>
<td>125.3 ± 8.6</td>
<td>.320</td>
</tr>
<tr>
<td>IR</td>
<td>63.1 ± 14.3</td>
<td>63.5 ± 13.1</td>
<td>.712</td>
</tr>
<tr>
<td>TM</td>
<td>187.3 ± 16.9</td>
<td>188.8 ± 17.3</td>
<td>.339</td>
</tr>
<tr>
<td><strong>Elbow</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flexion</td>
<td>146.5 ± 6.8</td>
<td>146.3 ± 5.8</td>
<td>.715</td>
</tr>
<tr>
<td>Extension</td>
<td>2.2 ± 5.2</td>
<td>1.6 ± 5.5</td>
<td>.212</td>
</tr>
</tbody>
</table>

<sup>a</sup>Data are mean degrees ± SD. ER, external rotation; IR, internal rotation; TM, total motion.
RESULTS

The results for the dominant and nondominant shoulder can be found in Tables 1 and 2, respectively. There was a significant reduction (P < .001) in dominant shoulder IR (−9.5°), total motion (−10.7°), and elbow extension (−3.2°) after pitching that remained present at 24 hours after pitching. No statistically significant differences were observed on the nondominant shoulder.

DISCUSSION

It is well recognized and reported that ROM adaptations are normal in the overhead throwing athlete. However, the precise cause of this adaptation has not been established. Numerous theories regarding the altered ROM pattern observed in overhead throwing athletes have been reported.1,3-5,6,18,19,21,25,31 Several authors have documented humeral retroversion in the thrower’s shoulder and attribute the altered ROM to bony adaptations.6,21,25 Some authors have theorized that the excessive ER and limited IR are due to anterior capsular laxity and posterior capsular tightness,3 although no clinical studies to date have shown this to be present. This theory of posterior capsular tightness has come into question from other researchers who have identified that ROM in baseball pitchers, specifically a loss of IR, does not correlate with an alteration in posterior glenohumeral translation.2,3

Anecdotally, it is the authors’ experience that baseball players often describe generalized tightness in the musculature of their posterior shoulders and elbow flexors after pitching. The muscles responsible for ER of the shoulder and flexion of the elbow exhibit high eccentric muscle activity10,11,15,28 during the throwing motion as the shoulder internally rotates between 6000 and 7000 deg/s7,8,22 and the elbow extends between 2000 and 5000 deg/s.9,30 Furthermore, Yanagisawa et al14 have shown long-lasting increased signal on T2-weighted MRIs of the supraspinatus, infraspinatus, and teres minor muscles after baseball pitching. The authors attribute these findings to muscle damage that resulted from eccentric muscle contractions.

Previous studies examining the effect of repetitive eccentric contractions have shown a subsequent loss of joint ROM in both the upper and lower extremities after testing.14,20,26 There are several postulated theories regarding this phenomenon, including a stretch-activated release of Ca2+ in muscle fibers,13 shortening of parallel noncontractile elements in the muscle,12,17 and a loss of motion due to an eccentric induced local inflammatory response and soft-tissue edema exerting strain on periarticular and epimysial connective tissue elements.15 Regardless of the mechanism, eccentric muscular contractions have been correlated to a rise in passive muscular tension and a loss of joint ROM.24

The results of the current study show a significant reduction in the amount of shoulder IR, total motion, and elbow extension ROM immediately after pitching. Although ROM was beginning to show a trend toward returning to baseline values, this significantly altered motion was still present 24 hours after pitching. These motions all involved high levels of eccentric muscle activity during pitching compared with the motions of shoulder ER and elbow flexion, which did not demonstrate changes in ROM after pitching. These findings may suggest that the altered ROM characteristics in baseball pitchers may be at least partially explained by adaptations of the soft-tissue musculature due to the high level of eccentric contractions observed during pitching, in addition to potential underlying bony or capsular adaptations.

Recently, reports have shown that baseball pitchers with documented rotator cuff internal impingement and painful shoulders exhibit decreased IR in their total motion arcs.19,27 Based on the results of these studies, as well as the results of the current study, we hypothesize that although an acute decrease in ROM may be a normal physiological response, baseball pitchers may be more susceptible to shoulder injury if they continue to pitch with decreased IR and total motion. The cumulative effects of eccentric microtrauma in the baseball pitcher may contribute to the pathological loss of shoulder IR and elbow extension ROM.

Clinically, acute static stretching after eccentric muscle activity has been shown to minimize loss of ROM.29 Thus, therapeutic techniques for injury prevention, such as stretching,26,29 light shoulder exercise,33 and ice,33 may be performed in an attempt to restore the athlete’s normal or preactivity ROM before having to pitch again. Future studies should be performed to prospectively assess this hypothesis.

Our ROM methods, including the use of a customized bubble goniometer, have shown good intratester reliability (0.8115-0.9740). Furthermore, because of the inherent SD of measurement associated with goniometry, we also used strict criteria to define significant results (P < .01) to minimize the chance of a type I statistical error. Testing was not performed during game situations. Although the current study demonstrated that ROM continues to be reduced at 24 hours after pitching, other authors have documented altered motion patterns of the upper and lower extremities for up to 4 days after various eccentric activities.13,14 Although baseball players often pitch with 24 hours of rest (relief pitchers do this routinely; starting pitchers may not compete every day yet often throw daily), future studies should continue to explore the duration of altered ROM after pitching, with and without therapeutic intervention.

CONCLUSION

The primary findings of the current study were that shoulder IR, total motion, and elbow extension ROM are significantly reduced immediately after baseball pitching. This decrease in ROM continued to be present 24 hours after pitching. The altered ROM corresponds with the muscle groups that show high eccentric activity during the act of pitching. This suggests that the altered ROM characteristics in baseball pitchers may be at least partially explained by soft-tissue musculotendinous adaptations due to muscle damage after eccentric contractions.

REFERENCES


