Effects of Non-Assisted Posterior Shoulder Stretches on Shoulder Range of Motion Among Collegiate Baseball Pitchers

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ABSTRACT

Maintenance of the posterior shoulder flexibility has implications for prevention of upper extremity injuries in athletes who use overhead throwing. Therefore, determination of stretching techniques that can be performed easily by these athletes and are most effective in improving flexibility is of great clinical interest. The purpose of this study was to evaluate the acute changes in glenohumeral internal rotation, external rotation, and horizontal adduction range of motion (ROM) after 3 on-the-field posterior shoulder stretches in 15 collegiate baseball pitchers. All stretches resulted in significant acute improvement in internal rotation and horizontal adduction ROM. However, there were no differences in improvements among the stretches. This study demonstrated that the acute increase in internal rotation and horizontal adduction ROM could be achieved by the non-assisted stretches. Non-assisted stretches can be performed without the aid from a clinician or a treatment table, and therefore can be used readily and frequently by baseball players of all levels.

Overhead pitching is a highly dynamic movement requiring a balance of strength and flexibility, as well as coordination of all body segments for optimal performance.[1-3] Baseball pitchers can generate arm velocities greater than 7000°/s,[4-7] producing shoulder and elbow distraction forces exceeding their body mass.[1,8] As a result of the high forces experienced at the upper extremity joints, physical examinations of athletes who use overhead throwing consistently demonstrates unilateral soft tissue adaptations, such as increased external rotation range of motion (ROM), decreased internal rotation, and horizontal adduction ROM in their throwing arms.[3-5,9-11]

It has been demonstrated that the bilateral difference in internal and external rotation ROM increase with age and with years of participation in sports with overhead throwing.[12] These changes are attributed to changes in both humeral torsion and soft tissue flexibility, specifically posterior shoulder tightness.[4,11-14] The association between shoulder and elbow injuries and glenohumeral joint ROM characteristics has been demonstrated in many studies.[15-20] Tightness of the posterior shoulder structures and decreased internal rotation ROM has been linked to nonspecific shoulder pain,[19] subacromial impingement,[16,21] superior labrum anterior to posterior lesions,[16,22] pathologic internal impingement,[17] and ulnar collateral ligament insufficiency[20] due to its altering effect on glenohumeral arthrokinematics[16,18,23] and scapulothoracic kinematics.[24] Although the change in ROM as a result of the humeral torsion is difficult to modify, changes due to soft tissue inflexibility can be modified through an implementation of a routine stretching program.[25,26]

Given the strong association between posterior shoulder tightness and various upper extremity injuries, many stretching techniques to improve posterior shoulder structures have been used among athletes using overhead throwing. The sleeper stretch is a stretching technique that has been used among baseball players for decades.[27-29]

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The stretch is typically performed while the participant is side lying with the stretching arm flexed to 90° and elbow flexed to 90°. Stretching occurs when the forearm is passively pushed into internal rotation. Shoulder flexion angle can be altered to target different portions of the posterior shoulder structure.[28] Horizontal cross-arm stretching is another stretching technique commonly used to improve posterior shoulder flexibility.[15] The stretch is performed by passively adducting the arm across the chest. Scapular stabilization is crucial for this stretch when maximizing the stretching of the posterior shoulder structures because it helps isolate the glenohumeral joint. Therefore, scapular stabilization is often achieved through manual stabilization by a clinician or by having the athletes press the lateral border of the scapula against the treatment table when side lying, providing self-stabilization.

Several studies have evaluated both the acute and long-term effects of the posterior shoulder stretches.[25,26,30,31] Laudner et al[30] examined the acute effects of the clinician-assisted sleeper stretch and demonstrated that performing 3 sets of a 30-second stretch resulted in 3.1° and 2.3° of improvement in internal rotation ROM and horizontal adduction ROM, respectively. Although acute increases in ROM from a single bout of stretching do not directly translate to a long-term improvement in ROM, the study supported the belief that regular performance of a clinician-assisted stretching exercise could improve posterior shoulder flexibility.

McClure et al[31] conducted a randomized control study assessing the effectiveness of the 2 types of stretching exercises performed during a 4-week intervention period. The authors reported that individuals who performed the cross-body stretch improved internal rotation ROM, whereas the individuals who performed the sleeper's stretch did not show clear improvement. A limitation of the study was that it was conducted on a general population who did not display the typical ROM characteristics of the overhead athletes. Specifically, the group did not display the deficits in internal rotation and horizontal adduction ROM on the dominant shoulder.

Lintner et al[25] assessed ROM characteristics of the professional baseball players who enrolled in a daily stretching program and reported that the athletes who had been enrolled in the program for more than 3 years had significantly greater internal rotation ROM compared with the athletes who were enrolled for less than 3 years. Kibler and Chandler[26] also reported improvement in both internal and external rotation ROM in elite tennis players who complied with a stretching program. These studies clearly demonstrate that a stretching program performed on a regular basis can improve or help maintain posterior shoulder flexibility in overhead-throwing athletes.

In all of the studies discussed above, posterior shoulder stretching was performed with the aid of a clinician. In addition, most of the stretches were performed while participants were in a supine or side lying position on a treatment table. A clinician-assisted stretch performed on the treatment table has the advantage that scapular stabilization can be ensured during the stretches. However, the disadvantages of these stretches are that athletes cannot perform the stretches independently and stretching cannot be performed on the field as part of a warm-up or cool-down routine. With a slight modification to the clinician-assisted stretches, the posterior shoulder stretches can be performed independently without the use of the treatment table. Specifically, these stretches can be performed while standing and having the athlete lean against a rigid wall (eg, a wall in a dugout or a bullpen, or a fence around the field). If acute improvement in glenohumeral ROM can be achieved from non-assisted stretches, athletes can perform posterior shoulder stretching more readily and frequently.[32]

Therefore, the purposes of this study were to evaluate the acute effects of 3 on-the-field non-assisted posterior shoulder stretches, specifically the sleeper stretch at 90° of shoulder flexion, the sleeper stretch at 45° of shoulder flexion, and the horizontal cross-arm stretch, on glenohumeral ROM and to determine which stretch resulted in the greatest improvement in internal rotation and horizontal adduction ROM. The posterior shoulder stretches were chosen based on a clinical recommendation by several certified athletic trainers working with athletes using overhead throwing and the ability of the exercises to be performed independently on the field. We hypothesized that all 3 stretches would result in improvements in internal rotation and horizontal adduction ROM. In addition, we hypothesized that the sleeper stretches would result in greater improvements in internal rotation ROM compared with the horizontal cross-arm stretch, and that the horizontal cross-arm stretch would result in greater improvement in horizontal adduction ROM compared with the sleeper stretches due to the positioning of the arm and the direction of joint motion while stretching.

METHOD

Participants

Fifteen male collegiate baseball pitchers (11 right-handed, 4 left-handed; mean age = 20.40±1.35 years; mean height = 1.86±0.06 m; mean mass = 91.30±10.26 kg; mean pitching experience = 10.26±2.40 years) participated. All participants were physically active and had been pitching and participating on an organized baseball team for more than 5 years. No pitcher reported a recent history (within 1 year) of upper extremity injury or surgery. The hand dominance was defined as the limb used to throw a ball.

Instrumentation

A Digital Inclinometer (Saunders Group, Chaska, Minn) was used to measure internal and external rotation and horizontal adduction ROM.

Procedure

All testing was performed in a university research laboratory. Prior to testing, each participant signed an informed consent form approved by the university's institutional review board. All participants attended 3 testing sessions, at least 2 days apart, which consisted of performing 1 of the 3 posterior shoulder stretches, assessments of internal and external rotation, and horizontal adduction ROM before and after the stretch. All stretches were counterbalanced to ensure that the order effect did not confound the study results. During each session, the internal and external rotation and horizontal adduction ROM were measured on the dominant shoulder by the same 2 examiners. In addition, ROM on the nondominant shoulder and the dominant shoulder was assessed at the beginning of the first session to demonstrate that our sample of baseball pitchers had ROM characteristics that are consistent with previous research. Testing of all participants occurred during their off-season participation.

To begin passive internal and external rotation ROM measurements, all participants were positioned supine on the treatment table with their tested arm in 90° of shoulder abduction[33] and 90° of elbow flexion. The examiner positioned the arm and stabilized the scapula by applying a posteriorly directed force against the participant's coracoid process and clavicle with the palm of his or her hand[34] to prevent elevation and anterior-posterior tilting of the scapula.[33] The second examiner then measured and recorded the angle of humeral internal or external rotation ROM with the digital inclinometer. Three measurements were taken per limb.

Horizontal adduction ROM was assessed while the scapula was stabilized in a retracted position.[35] The participant lay supine on the treatment table and the examiner stood on the side of the shoulder being tested. The participant was asked to lift the tested shoulder off the table so the testing examiner could wedge a hand under the scapula to grasp the lateral boarder of the scapula. The examiner stabilized the scapula in a retracted position by placing the thenar eminence on the lateral boarder of the scapula and applying a downwardly (toward the table) and inwardly (toward the spine) directed force.[35] The examiner used the other hand to passively move the participant's arm into horizontal adduction. At the end of the ROM, the second examiner recorded the angle formed between the humerus and the horizontal plane from the superior aspect of the shoulder. Three measurements were taken per limb.

After the pretest measurements were completed, the participant immediately performed 1 of the 3 posterior shoulder stretches assigned to the testing session. The examiner first demonstrated and explained the appropriate stretching technique, gave instructions to each participant, and answered any questions. Each stretch was repeated 3 times and held for 30 seconds,[32] with 30 seconds of rest period in between trials, as timed using a stopwatch. A valid stretch was determined by ensuring proper positioning by the examiners and verbal feedback from the participant indicating when a stretch was felt in the posterior shoulder.

To perform a horizontal cross-arm stretch, the participant stood with the dominant shoulder and lateral border of their scapula against a wall. The dominant shoulder was flexed to 90° and passively horizontally adducted by the participant to end range using the contralateral arm[21] (Figure 1). Proper stabilization of the scapula was ensured by having the participant lean against the wall using his body weight, preventing the scapula from following the humerus across the body.[36]

To perform a standing sleeper stretch at 90°, the participant stood with the dominant shoulder against the wall and flexed to 90° with elbow in 90° of flexion (Figure 2). The participant leaned against the wall applying pressure to the lateral border of the scapula while the head and neck remained in a neutral position, looking straight ahead. The scapula remained pressed against the

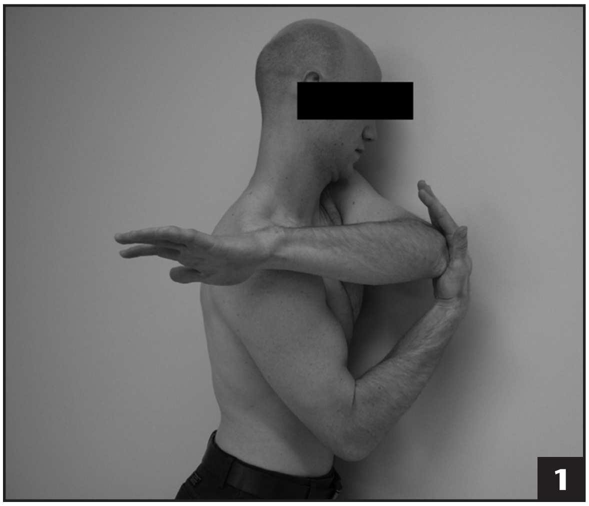

Figure 1. Performance of horizontal cross-arm stretch. The dominant shoulder was flexed to 90° and passively horizontally adducted to end range using the contralateral arm.

Figure 2. Performance of a standing sleeper stretch at 90°. The shoulder was flexed to 90° with elbow in 90° of flexion. Contralateral arm was used to stretch the arm into internal rotation.

Figure 3. Performance of a standing sleeper stretch at 45°. The shoulder was flexed to 45° with elbow in 90° of flexion. Contralateral arm was used to stretch the arm into internal rotation.

wall while the participant used the contralateral hand to rotate the dominant shoulder into internal rotation. A standing sleeper stretch at 45° was performed in a similar manner as the standing sleeper stretch at 90°, except that the participant's dominant shoulder was flexed to 45°, instead of 90° (Figure 3). Post-stretch ROM measurements were performed immediately following the completion of the last set of stretch (within 1 to 2 minutes).

Data Reduction

Three-trial means of the dominant limb internal and external rotation and horizontal adduction ROM were calculated to represent the values for each participant for each session (pre versus post) and stretch-type (sleeper stretch at 90° versus sleeper stretch at 45° versus horizontal cross-arm stretch). In addition, 3-trial means for the internal and external rotation, horizontal adduction ROM, and total rotation ROM (internal rotation + external rotation) for the dominant and nondominant shoulders were calculated for the first testing session.

Data Analysis

Paired *t* tests were used to compare the dominant and nondominant ROM values obtained prior to stretching during the first testing session to demonstrate that the sample of baseball players who participated in this study demonstrated the characteristic ROM alterations reported in the literature. Three separate 2-way repeated-measures analysis of variance were performed to determine presence of interaction and main effects in internal and external rotation and horizontal adduction ROM. All statistical analyses were performed using SPSS version 13.0 software (SPSS Inc, Chicago, Ill). An alpha level of .05 was set prior to the study.

RESULTS

The sample of baseball pitchers who participated in this study exhibited significantly less internal rotation (mean difference ± standard deviation [SD] = 12.4°±11.5°, $P <$ .001), horizontal adduction (3.8°±4.3°, $P <$ .001), and total rotation ROM (9.5°±11.8°, $P =$ .008) in their dominant throwing shoulder compared with their nondomi-

TABLE

Internal and External Rotation Range of Motion and Posterior Shoulder Tightness Measurements Before and After the 3 Stretches

	PRESTRETCH		POSTSTRETCH		DIFFERENCE		
RANGE OF MOTION	MEAN	±SD	MEAN	± SD	MEAN	±SD	P
Internal rotation (°)							
Horizontal cross-arm	36.7	11.1	41.1	10.5	4.4	5.6	
Sleeper stretch 90°	38.6	10.6	42.5	8.9	3.8	4.8	
Sleeper stretch 45°	35.4	11.6	40.0	11.4	4.6	5.5	
Group means	36.9	10.9	41.2	10.1	4.3	5.2	< .001
External rotation (°)							
Horizontal cross-arm	119.4	10.6	119.5	11.1	0.1	4.9	
Sleeper stretch 90°	118.8	12.9	119.8	11.9	0.9	3.5	
Sleeper stretch 45°	117.8	8.0	116.7	10.3	–1.1	5.0	
Group means	118.7	10.4	118.7	11.0	0.02	4.5	.971
Horizontal adduction (°)							
Horizontal cross-arm	96.4	3.4	100.6	5.0	4.2	3.4	
Sleeper stretch 90°	94.9	5.1	98.0	5.1	3.1	4.4	
Sleeper stretch 45°	96.2	5.3	99.1	5.4	2.9	4.3	
Group means	95.8	4.7	99.2	5.2	3.4	4.0	< .001

nant shoulder. The external rotation ROM was significantly greater on the dominant shoulder compared with the nondominant shoulder (3.7°±6.2°, $P < .001$).

The prestretch and poststretch internal and external rotation and horizontal adduction ROM measurement results are presented in the Table. There was no significant stretch by session (prestretch versus poststretch) interaction for internal rotation ($P = .919$), external rotation ($P = .494$), or horizontal adduction ROM ($P = .536$). However, there were significant session main effects for internal rotation ROM (4.3°±5.2°, $P < .0001$) and horizontal adduction ROM (3.4°±4.0°, $P < .0001$). Glenohumeral internal rotation and horizontal adduction ROM significantly increased following stretching. There was no significant session main effect for external rotation ROM (0.02°±4.5°, $P = .971$).

DISCUSSION

The sample of baseball pitchers in this study presented with a 12.4° deficit of internal rotation ROM, 9.5° deficit of total rotation ROM, and a 3.9° deficit of horizontal adduction ROM in the throwing shoulder compared with the nonthrowing shoulder. This pattern is consistent with the characteristics of a baseball pitcher's shoulder described in the literature.[4,35,37-42] The deficit in the internal rotation ROM alone may be attributed to a bilateral difference in the humeral torsion.[14] However, bilateral deficit in total rotation ROM clearly demonstrates that the pitcher's dominant shoulder had greater soft tissue tightness compared with the nondominant side.[14] Therefore, the baseball pitchers who participated in this study represent a typical collegiate baseball pitcher, which allows the result of this study to be generalized to a wider population.

The results of our study were in agreement with our initial hypothesis that all 3 stretches would result in improvement of internal rotation and horizontal adduction ROM. The stretching resulted in a mean improvement of 4.3° in internal rotation ROM and 3.4° in horizontal adduction ROM. These observed improvements are comparable to or slightly greater than that reported after the clinician-assisted sleeper stretch in a study by Laudner et al.[30] The duration and number of repetitions for the stretches were the same in our study and the study by Laudner et al.[30] This indicates that similar acute effects in internal rotation and horizontal adduction ROM can be expected from the non-assisted stretches and the clinician-assisted stretches.

Contradicting our initial hypothesis that there would be differences among the stretches due to the positioning of the arm and the direction of joint motion while stretching, we did not observe differences in ROM improvements among the 3 stretching techniques. The sleeper stretch at 90° is designed to stabilize the scapula while stretching the posterior rotator cuff muscles and the posterior inferior capsule-glenohumeral ligament in the shoulder.[27] The sleeper stretch at 45° is a modification of the original sleeper stretch performed with 90° flexion, which is preferred when the sleeper stretch at 90° produces discomfort from tissue impingement.[28] The stretching sensation is felt lower in the posterior shoulder and there is more triceps involvement with the sleeper stretch at 45°.[28] The horizontal cross-arm stretch is considered to stretch the posterior musculature to a greater degree than the posterior inferior capsule.[21] Although these stretches might focus on slightly different portions of the posterior shoulder due to joint positioning, they all result in separation between the posterior glenoid and the humerus, resulting in elongation of the posterior shoulder structures. Perhaps this is why the 3 stretches resulted in a similar increase in glenohumeral internal rotation and horizontal adduction ROM. The results suggest that athletes can perform any of the 3 non-assisted stretches to acutely improve posterior shoulder flexibility. The sleeper stretch at 45° or the horizontal adduction stretch may be recommended if the athletes experience discomfort when performing the sleeper stretch at 90°.

Shoulder musculoskeletal adaptations commonly occur in baseball pitchers due to highly dynamic repetitive throwing movement. Because of the repetitive stress applied to the shoulder, baseball pitchers' shoulder undergo musculoskeletal adaptations, specifically increased tightness of the posterior shoulder structures and increased humeral torsion that manifests as decreased glenohumeral internal rotation and horizontal adduction ROM.[4,11,13,35,37-42] Meister et al[12] assessed glenohumeral rotation ROM characteristics in adolescent baseball players between the ages of 8 and 16 and demonstrated that the average internal rotation ROM in the 16-year-old children were almost 18° less than that of the 8-year-old children. Perhaps this decline in internal rotation ROM is a combined effect of increasing humeral torsion developed in response to the repetitive torsional stress applied to the humerus from throwing[4,11,13,43] and gradual tightening of the soft tissue from maturation and baseball participation.[12]

Posterior shoulder stretching has been implemented by the clinicians treating professional baseball players, even prior to the appearance of literature that linked posterior shoulder tightness and various upper extremity injuries. Stretching of the posterior shoulder structures has been believed to help prevent upper extremity injuries in baseball players by normalizing the posterior shoulder flexibility, restoring normal glenohumeral arthrokinematics[16,18,23] and scapular kinematics.[24] Increased posterior shoulder flexibility and thus increased internal rotation ROM may also help decrease stress to the posterior shoulder muscles during the deceleration phase of pitching by increasing the time over which their throwing shoulder is decelerated, which may decrease the risk of injury.

The stretches chosen for this study were based on their ability to be performed on the field without the help of a clinician to provide scapular stabilization. Previous literature describes various stretching techniques that require the help of a clinician to manually provide scapular stabilization.[29-31,44,45] The limitations of the clinician-assisted stretching techniques are that the athletes cannot perform the stretches independently and that stretching cannot be performed on the field. There is a limitation to the number of athletes one clinician can assist with stretching. Although the clinician-aided stretching program may be appropriate in some settings, implementation of the program is not feasible in a setting where the clinician-to-athlete ratio is high, for example in high school and little league settings. The results of this study demonstrated that the non-assisted stretches resulted in acute improvements in internal rotation and horizontal adduction ROM comparable to what has been reported for a clinician-assisted stretching exercises.[30] This indicates that a large number of baseball players of all levels may be able to benefit from stretching by correctly performing the non-assisted posterior shoulder stretching. However, the long-term effect of the non-assisted stretch has not been evaluated in baseball pitchers.

An advantage of clinician-assisted stretching is that the clinician can ensure scapular stabilization through manual stabilization. Stabilization of the scapula is critical when performing posterior shoulder stretches because the stabilization helps to isolate the glenohumeral joint and allow stretching to occur in the soft tissues crossing the posterior shoulder. However, stabilization can also be achieved by pressing the scapula against a wall or a treatment table.[15,29] The stretches chosen for this study were all performed while standing against a wall for support. Therefore, a dugout wall can be used to perform the stretches on the field. Clinicians and baseball coaches may instruct the players to perform these stretches on the field before and after games or between innings for the maintenance of their posterior shoulder flexibility. The clinician-assisted sleeper stretches, although effective, do not allow pitchers to perform these stretches on the field without the availability of a treatment table. One weakness of the non-assisted stretches is that the amount of force pitchers use to stretch their shoulders cannot be monitored or controlled for. On the other hand, the non-assisted stretching allows the pitchers to control the amount of force for them to feel the stretch. It was the intent of the current study to allow the pitchers to apply the self-selected amount of force to feel the stretch in their posterior shoulder because this is the way pitchers would normally perform the stretches on the field, which makes this study clinically meaningful.

We recognize limitations within our study. One limitation was that the effects of non-assisted stretches were not compared with clinician-assisted stretches. Instead, the values were compared with previously reported values.[30] Incorporating the clinician-assisted stretches in this study would have strengthened the point that similar improvements in ROM and posterior shoulder flexibility can be achieved from the non-assisted and clinician-assisted stretches. Another limitation was that the lack of control group leaves room for speculation that the prestretching ROM assessment, performed by passively moving the pitchers' shoulder to an end-range, may have resulted in tissue stretching and thereby affected the post-stretching ROM measurement. However, this is unlikely because the external rotation ROM did not change after the prestretching external rotation ROM assessment. A similar study conducted by Laudner et al[30] that examined the effects of clinician-assisted sleeper stretches used a control group that did not perform any stretching between the ROM assessments. The ROM in the control group participants did not differ between the prestretching and poststretching measurements.[30]

This study demonstrated that non-assisted stretching could acutely improve internal rotation and horizontal adduction ROM. Because the non-assisted stretch can be performed independently without access to a clinician or a treatment table, baseball players of all levels can perform these stretches more readily and frequently. Future studies need to investigate the long-term effect of non-assisted stretches on internal rotation ROM and posterior shoulder flexibility and the effect of a stretching program on injury risk using a prospective cohort study design.

CONCLUSION

The current study has demonstrated that performing a single session of the posterior shoulder stretch (three 30-second bouts) is adequate to acutely increase internal rotation and horizontal adduction ROM. There were no differences in improvements in internal rotation and horizontal adduction ROM among the 3 non-assisted stretches examined in this study (sleeper stretch at 90° and 45° and horizontal cross-arm stretch). Therefore, athletes can perform any of the 3 stretches to improve posterior shoulder flexibility, given the stretches are performed correctly with proper scapular stabilization.

IMPLICATIONS FOR CLINICAL PRACTICE

The 3 self-stretches (sleeper stretch at 90° and 45° and horizontal cross-arm stretch) resulted in acute improvements in posterior shoulder flexibility. With proper instruction, athletes can perform these stretches on their own to help maintain posterior shoulder flexibility. ■

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