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A Randomized Controlled Comparison of Stretching Procedures for Posterior Shoulder Tightness

Posterior capsule tightness of the shoulder has been suggested as a causative or perpetuating factor in shoulder impingement syndrome and labral lesions.^{13,15,23,25,30-32} Harryman et al¹⁴ have shown that selective tightening of the posterior portion of the shoulder capsule causes anterior and superior translation of the humeral head with passive shoulder flexion. The abnormal humeral head motion can result in a decrease in the subacromial space during overhead

activities. This approximation of the humeral head and acromion can lead to compression of tissues in that region and may be associated with limited shoulder flexion, internal rotation, and horizontal adduction.²⁷

Warner et al²⁸ found that patients with shoulder impingement syndrome were limited in passive internal rotation range of motion (ROM) compared to healthy subjects and attributed this limitation to posterior capsular tightness. Myers et al²⁰ demonstrated that throwing athletes with symptomatic internal impingement had reduced glenohumeral internal rotation and also reduced glenohumeral adduction reflecting posterior shoulder tightness compared to matched asymptomatic subjects. Burkhart et al^{5,7} suggest that contracture of the posterior-inferior glenohumeral capsule, evidenced by a lack of internal rotation with the arm abducted to 90°, is an essential cause of superior labral lesions. This assertion was based on a large series (n = 124) of throwers with arthroscopically proven superior labral lesion, all of whom demonstrated at least a 25° lack of shoulder internal rotation compared to the non-throwing side.^{5,7} The authors suggest that a tightened posterior-inferior capsule pushes the humeral head superiorly and posteriorly with the arm in the cocked throwing position, and this concept has

● **STUDY DESIGN:** Randomized controlled trial.

● **OBJECTIVES:** To compare changes in shoulder internal rotation range of motion (ROM), for 2 stretching exercises, the “cross-body stretch” and the “sleeper stretch,” in individuals with posterior shoulder tightness.

● **BACKGROUND:** Recently, some authors have expressed the belief that the sleeper stretch is better than the cross-body stretch to address glenohumeral posterior tightness because the scapula is stabilized.

● **METHODS:** Fifty-four asymptomatic subjects (20 males, 34 females) participated in the study. The control group (n = 24) consisted of subjects with a between-shoulder difference in internal rotation ROM of less than 10°, whereas those subjects with more than a 10° difference were randomly assigned to 1 of 2 intervention groups, the sleeper stretch group (n = 15) or the cross-body stretch group (n = 15). Shoulder internal rotation ROM, with the arm abducted to 90° and scapula motion prevented, was measured before and after a 4-week intervention period. Subjects in the control group were asked not to engage in any new stretching activities, while subjects in the 2 stretching groups were asked to perform

stretching exercises on the more limited side only, once daily for 5 repetitions, holding each stretch for 30 seconds.

● **RESULTS:** The improvements in internal rotation ROM for the subjects in the cross-body stretch group (mean ± SD, 20.0° ± 12.9°) were significantly greater than for the subjects in the control group (5.9° ± 9.4°, P = .009). The gains in the sleeper stretch group (12.4° ± 10.4°) were not significant compared to those of the control group (P = .586) and those of the cross-body stretch group (P = .148).

● **CONCLUSIONS:** The cross-body stretch in individuals with limited shoulder internal rotation ROM appears to be more effective than no stretching in controls without internal rotation asymmetry to improve shoulder internal rotation ROM. While the improvement in internal rotation from the cross-body stretch was greater than for the sleeper stretch and of a magnitude that could be clinically significant, the small sample size likely precluded statistical significance between groups. *J Orthop Sports Phys Ther* 2007;37(3):108-114. doi:10.2519/jospt.2007.2337

● **KEY WORDS:** internal rotation, shoulder, stretching, tightness

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been supported in a biomechanical study using a cadaver model.¹³

Morrison et al¹⁷ suggest that adequate flexibility of the posterior capsule is important prior to beginning a strengthening program. Several different methods of stretching have been described to address posterior shoulder tightness. These include the “towel stretch,” where the glenohumeral joint is adducted, internally rotated, and extended, while the hand now located behind the individual’s back is pulled up by the opposite hand using a towel.^{3,16} Another popular stretch is the “cross-body stretch,” where the shoulder is elevated to approximately 90° of flexion and pulled across the body into horizontal adduction with the opposite arm.³ Both of these stretching procedures have been criticized because the scapula is not stabilized and therefore tissue stress is imparted to scapulothoracic tissues as well as tissues crossing the glenohumeral joint. More recently, authors^{2,5,29} have described a “sleeper stretch” that is accomplished by lying on the side to be stretched, elevating the humerus to 90° on the support surface, then passively internally rotating the shoulder with the opposite arm. Other authors³¹ have described methods where the scapula is manually stabilized by the therapist while the arm is adducted or internally rotated. This manual approach has the obvious disadvantage of requiring a therapist or second person to perform the stretch, which limits how often the stretch can be performed.

Despite the evidence from biomechanical studies suggesting that posterior shoulder tightness may be a contributing factor to subacromial impingement and the recommendation of authors for prophylactic stretching, we could find no studies comparing the effectiveness of these stretching procedures for posterior shoulder tightness. Therefore, the purpose of this study was to compare the sleeper stretch and cross-body stretch techniques to improve passive shoulder internal rotation ROM in subjects with limited shoulder internal rotation ROM

presumably due to posterior shoulder tightness.

METHODS

WE USED A RANDOMIZED DESIGN to compare 2 posterior shoulder-stretching techniques performed for 4 weeks in subjects with unilateral posterior shoulder tightness. We compared these groups to a nontreated control group without unilateral tightness.

Subjects

From a convenience sample of college students, 83 individuals were measured to identify 30 with a 10° (right versus left) asymmetry in shoulder internal rotation measured at 90° abduction. These 30 subjects with a 10° or greater difference were, after stratification, randomly assigned to 1 of 2 intervention groups: the sleeper stretch group (n = 15) or the cross-body stretch group (n = 15). Subjects were first stratified based on gender and involvement in overhead sports because these factors are believed to influence shoulder ROM. The control group (n = 24) consisted of subjects with a between-shoulder difference of less than 10° of internal rotation measured at 90° of abduction. After the initial 24 control subjects without a significant asymmetry were identified, only subjects with asymmetry were invited to participate in the study to avoid excessive imbalance

between group sizes. Therefore the final sample consisted of 54 subjects (20 males, 34 females). Exclusion criteria consisted of a history of shoulder surgery, shoulder symptoms requiring medical care within the past year, or shoulder pain greater than 5 out of 10 using a numerical pain scale. Detailed characteristics of each subject group are given in **TABLE 1**. All subjects read and signed an informed consent document approved by the Arcadia University Institutional Review Board prior to participation in the study.

Measurements Procedures

All measurements were performed by 1 of 2 testers who were blind to treatment group. The same tester performed both pretest and posttest measurements on a given subject. Both testers established intrarater reliability on a group of 15 asymptomatic subjects (30 shoulders) by repeating measurements at least 1 day apart. Separate reliability coefficients (intraclass correlation coefficients [ICC_{3,1}]) and standard error of measurement [SEM]) were established for each rater and each side for each measurement (**TABLE 2**). Prior to range of motion testing, subjects were asked to warm up by performing 3 active, bilateral shoulder flexion stretches with hands clasped, holding each for 10 seconds.

Our primary measure of posterior shoulder tightness was passive internal rotation of the glenohumeral joint with

TABLE 1

SUBJECT CHARACTERISTICS

	Control (n = 24)	Sleeper Stretch (n = 15)	Cross-Body Stretch (n = 15)
Gender (male, female) (n)	10, 14	6, 9	4, 11
Engage in overhead sports (n)	5	3	3
Age (y)*	23.5 (1.8)	23.5 (1.7)	22.9 (1.5)
Height (cm)*	172.2 (10.1)	168.7 (9.2)	167.5 (8.3)
Body mass (kg)*	71.1 (15.0)	70.3 (12.2)	68.8 (12.6)
Dominant arm (right, left) (n)	24, 0	13, 2	12, 3
Side stretched (right, left) (n)		7, 8	7, 8
Compliance (%)*		81.0 (16.0)	88.9 (10.0)

*Values represented as mean (SD). No significant differences were found for age, height, and body mass among groups.

TABLE 2

**INTRACLASS CORRELATION COEFFICIENTS (ICC)
AND STANDARD ERROR OF MEASUREMENTS (SEM)
FOR SHOULDER ROTATION**

Measurement	Rater 1		Rater 2	
	ICC _{3,1}	SEM*	ICC _{3,1}	SEM*
IR90 left	0.84	4.8	0.80	5.4
IR90 right	0.82	4.3	0.75	5.6
ER90 left	0.88	4.4	0.89	4.6
ER90 right	0.78	4.8	0.86	3.7
Total Rot left	0.98	3.4	0.96	4.8
Total Rot right	0.91	6.5	0.89	6.7
TUB left	0.96	0.03	0.91	0.04
TUB right	0.90	0.04	0.96	0.03

Abbreviations: ER90, external rotation at 90° abduction; IR90, internal rotation at 90° abduction; Total Rot, total rotation calculated as the sum of IR90 and ER90; TUB, thumb up the back.

**All values represent degrees except TUB measures, which are percent of total spine length.*

the arm abducted to 90° in the frontal plane (IR90) as shown in **FIGURE 1**. The inclinometer was placed on the dorsal surface of the forearm with the elbow flexed to 90°. We were careful to prevent scapular substitution by watching the anterior aspect of the shoulder during the measurement. Accordingly, the end point for IR90 measurement was the angle just prior to the anterior aspect of the shoulder moving anteriorly, indicating scapular motion.¹ Shoulder external rotation was measured in the same fashion, with the arm abducted to 90° in the frontal plane (ER90). Total rotation was calculated by adding the IR90 and ER90 values.



FIGURE 1. Measurement of passive internal rotation with the shoulder abducted 90° in the frontal plane (IR90). The examiner was careful to stop the movement at the point where the anterior aspect of the shoulder (dotted line) was observed to move anteriorly.

We also measured the ability to actively move the thumb up the back (TUB), as shown in **FIGURE 2**. Rather than using vertebral level as an end point, which may be unreliable,¹⁰ we quantified the measure according to spine length. Prior to asking the subject to move the thumb up the back, we measured the length of the spine from the first thoracic spinous process (T1) to the level of the iliac crests (IC) at midline, which were determined by palpation and marked. The TUB mea-

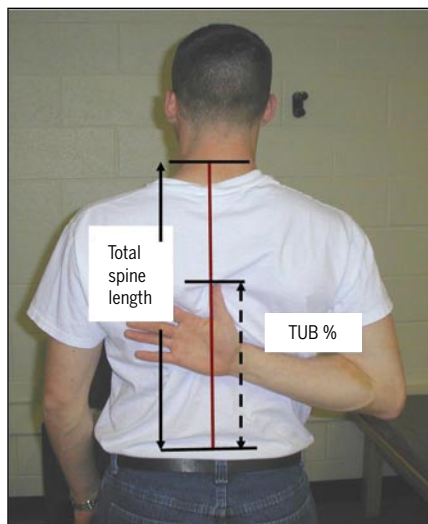


FIGURE 2. Thumb-up-the-back (TUB) measurement. The total length of the spine from the first thoracic spinous process to the level of the iliac crests at midline was determined by palpation and marked. The TUB measure is expressed as a percentage of total spine length.

sure was normalized and expressed as a percentage of spine length based on the following formula: $TUB = (\text{distance from T1 to IC} - \text{distance from thumb to T1}) / \text{distance from T1 to IC}$.

Stretching Intervention

After the initial measurements, the intervention team assigned subjects to the control group if the IR90 difference between sides was less than 10°, and randomly assigned subjects to 1 of the 2 stretching groups if the difference between sides was greater than 10°. One group performed the sleeper stretch by lying on the side to be stretched, elevating the humerus to 90° on the support surface, then passively internally rotating the humerus with the opposite arm (**FIGURE 3A**). The other group performed a cross-body stretch by passively pulling the humerus across the body into horizontal adduction with the opposite arm (**FIGURE 3B**). Subjects in the control group were asked not to engage in any new stretching activities while subjects in the 2 stretching groups were asked to perform stretching exercises to a point of mild discomfort, on the more limited side only, once daily for 5 repetitions, holding each stretch for 30 seconds.

Subjects in both stretching groups were shown their assigned exercise, which they were asked to demonstrate. They were also given a sheet with written instructions and a picture of the stretch to be performed. All subjects in the stretching groups were given a daily log to be completed to reflect exercise compliance and were encouraged to fill them out accurately rather than overestimating compliance to please the investigators. All subjects were also contacted at 2 weeks for encouragement and to schedule the final test session.

At the final test session all measurements were taken again by the same tester, who took the original measures and was blind to treatment group assignment. Compliance logs were collected and percentage compliance was computed based on the number of days the subjects completed the daily stretching program. Subjects in the stretching groups completed a

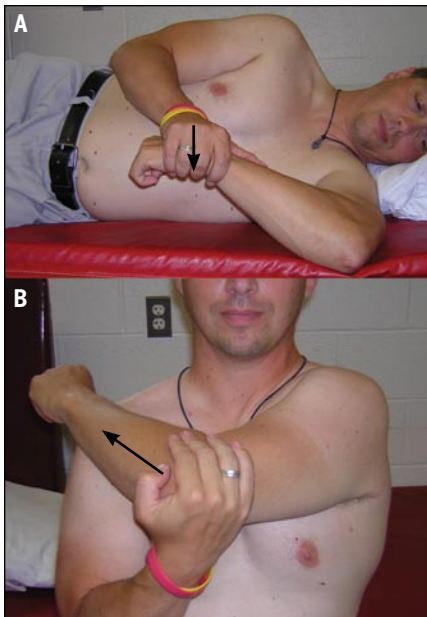


FIGURE 3. (A) Sleeper stretch, (B) cross-body stretch. The subjects in the 2 stretching groups were asked to perform stretching exercises to a point of mild discomfort, on the more limited side only, once daily for 5 repetitions, holding each stretch for 30 seconds.

brief form which asked about their subjective response to the stretching program.

Data Analysis

Descriptive statistics were calculated for all variables and all dependent variables were checked for normal distribution and homogeneity of variance assumptions. Change scores were also calculated for all ROM variables by subtracting pretest values from posttest values. To determine equivalency among groups, differences for subject characteristics were assessed using a 1-way analysis of variance (ANOVA). To compare the effect of the stretching exercises among the 3 groups, a mixed 2-way analysis of variance (group by time) was performed. If a group-by-time interaction was found, a follow-up between-group 1-way analysis of variance was performed using change scores as the dependent variable and Tukey post hoc tests for comparisons among groups. To compare between sides (stretched or not stretched) in the 2 stretching groups, a mixed 2-way analysis of variance (group by side) was performed on the change scores for each side and group.

RESULTS

NO SIGNIFICANT DIFFERENCES WERE found for age, height, and body mass among groups (TABLE 1). Only 1 out of 5 subjects in each group was actively involved in sports requiring overhead use of the arm. The 2 stretching groups were not perfectly balanced on gender due to an error in the stratification process. All dependent variables met the assumptions for ANOVA testing. The values for all dependent variables are shown in TABLE 3 and the change scores for IR90 are shown graphically in FIGURE 4. For IR90, the group-by-time ANOVA revealed a significant interaction ($P < .001$). The cross-body stretch group improved significantly more (mean \pm SD, $20.0^\circ \pm 13.0^\circ$) than the control group (mean \pm SD, $5.8^\circ \pm 8.5^\circ$, $P = .009$). The gains in sleeper stretch group (mean \pm SD, $12.4^\circ \pm 11.9^\circ$) were not significant compared to controls ($P = .586$) and the differences (7.6°) between the cross-body stretch group and the sleeper stretch group were not statistically significant ($P = .148$). Both stretching groups showed a significant increase in IR90 on the stretched side compared to the nonstretched control side ($P < .001$), but there was no side-by-group interaction, indicating that relative to the nonstretched side there was no difference between methods of stretching.

There were no significant differences between the pretest and posttest ER90 measures in the 3 groups, nor were there significant differences between the treated and nontreated arms (TABLE 3). Total rotation showed a significant group-by-time interaction ($P < .001$) and follow-up testing revealed a significant difference between controls and the cross-body stretch group ($P = .026$), while other differences between groups were not significant. Both stretching groups showed a significant increase in total rotation relative to the nonstretched side (TABLE 3). For the TUB measure, there was a significant main effect of time ($P = .044$) and follow-up analysis revealed that only the sleeper stretch group made a statistically signifi-

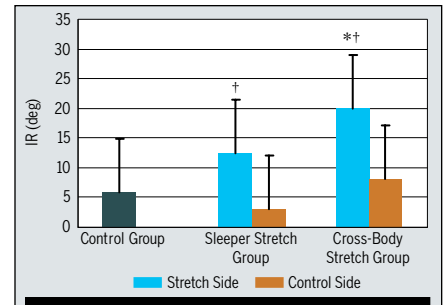


FIGURE 4. Changes in IR90 over the 4-week stretching period for all groups. Positive changes represent increased motion. Control group values represent the average of both right and left sides. Error bars represent standard deviation. *Significant change on stretch side compared to control group ($P < .01$); †Significant change compared to control side ($P < .001$).

cant increase ($P = .028$). The gain in TUB for the sleeper stretch group (2.7%) was also statistically significant relative to the control side ($P = .048$), while the small change in the cross-body stretch group (1.6%) was not significant compared to the control side (TABLE 3).

DISCUSSION

ALTHOUGH BOTH STRETCH GROUPS showed increases in IR90 compared to the nonstretched side, the cross-body stretch appeared to be more effective and showed the only significant increase compared to the control group. This finding is somewhat surprising, given that stabilization of the scapula as performed with the sleeper stretch would seem to enhance the effectiveness of stretching for the posterior shoulder region. Average self-reported compliance for the cross-body stretch group was 89% compared to 81% for the sleeper stretch group, which was not statistically different. Three out of 15 subjects in the sleeper stretch group complained that the stretch itself was painful, whereas only 1 subject in the cross-body stretch group reported pain during stretching, which she attributed to a minor injury and not to the stretch itself. One subject in each stretching group reported new symptoms during the stretching period, but neither could attribute the symptoms to a particular activity. One subject in the sleeper group re-

TABLE 3
RANGE OF MOTION BEFORE AND AFTER A 4-WEEK STRETCHING PROGRAM USING EITHER THE SLEEPER STRETCH OR THE CROSS-BODY STRETCH*

Measures	Sleeper (n = 15)		Cross-Body (n = 15)		Controls (n = 24) [†]	
	Preintervention	Postintervention	Preintervention	Postintervention	Preintervention	Postintervention
IR90, stretch side	48.2 ± 8.8	60.6 ± 10.4 [§]	46.6 ± 11.5	66.6 ± 15.9 [§]	52.5 ± 9.5	58.3 ± 8.8
IR90, control side	61.8 ± 9.5	64.8 ± 12.8	60.5 ± 10.6	68.6 ± 13.7		
ER90, stretch side	95.1 ± 14.5	96.1 ± 12.7	99.1 ± 9.1	97.5 ± 8.0	92.7 ± 16.6	93.0 ± 15.2
ER90, control side	93.0 ± 11.4	95.6 ± 12.4	98.2 ± 11.0	99.4 ± 7.5		
Total Rot, stretch side	143.7 ± 17.9	156.9 ± 19.7 [§]	145.9 ± 17.1	164.3 ± 21.2 [§]	145.3 ± 22.9	151.7 ± 19.9
Total Rot, control side	155.0 ± 17.0	160.6 ± 18.1	158.9 ± 17.1	168.3 ± 17.2		
TUB, stretch side	66.5 ± 10.8	69.2 ± 9.2 [§]	68.9 ± 13.0	70.5 ± 11.3	67.5 ± 13.8	68.7 ± 13.9
TUB, control side	67.2 ± 15.5	66.6 ± 13.1	71.4 ± 11.5	69.8 ± 10.8		

Abbreviations: ER90, external rotation at 90° abduction; IR90, internal rotation at 90° abduction; Total Rot, total rotation calculated as the sum of IR90 and ER90; TUB, thumb up the back, values represent percent of total spine length with higher numbers indicating the thumb was higher up the back.

*All values represent mean ± SD degrees except TUB measures, which are percent of total spine length.

[†] Control subjects did not stretch either side, therefore the average of left and right measurements were used.

[‡] Change preintervention-postintervention significantly different compared to control group ($P < .05$).

[§] Change preintervention-postintervention significantly different compared to control side ($P < .05$).

ported that the stretch was inconvenient because the position required prevented simultaneous reading, while all other subjects reported that they had adequate time to complete the stretching exercise. Four subjects in the sleeper stretch group reported increasing an exercise workout (1 aerobically, 1 more general stretching, 2 more intense strengthening) during the stretching period. Only 1 subject in the cross-body stretch group changed his/her exercise routine by swimming more regularly. Based on this self-report data, it is possible that subjects in the sleeper stretch group performed the stretch less intensely and for less time because of pain or the inconvenient position required.

Small differences in IR90 motion were observed in controls as well as in the nonstretched shoulders of the stretching groups. Measurement error or learning effects are most likely responsible for the differences between pretest and posttest scores. Despite these potential influences, clear differences in IR90 attributable to the stretching were observed between the cross-body stretch and control groups and between sides for both stretching groups. The difference in IR90 gains between the 2 experimental groups was about 8°, which could be considered a clinically meaningful difference. Using this mean difference and the standard de-

viation found in our sample, the power to detect a difference between the stretching groups was only 0.42. To obtain a power of at least 0.8 to detect an 8° difference between groups would have required a sample size of 36 subjects per group. Therefore, the failure to find a statistically significant difference between the experimental groups could be attributable to an inadequate sample size.

Despite clear gains in the IR90 measure, only minimal changes were observed in the TUB measure and only in the sleeper stretch group (2.7% spine length change, or 1.1 cm). We believe there is an anatomic explanation for this finding. Both stretching procedures were performed with the arm elevated to 90°. Cadaver studies have shown this position stresses the posterior-inferior aspect of the glenohumeral joint capsule.^{11,12} The TUB measure assesses internal rotation with the arm by the side that stresses the posterior-superior capsule, while keeping the inferior capsule relatively slack. Therefore, we believe that the TUB measure is more reflective of the length of the posterior-superior capsule, which was likely not stretched to a significant degree with our stretching procedures because of the elevated position of the arm. Muraki et al¹⁹ studied the strain within the posterior rotator cuff muscles during extreme

glenohumeral joint positions in cadavers and found that the supraspinatus underwent the greatest strain with the humerus by the side and maximally extended similar to the TUB position. However, the inferior fibers of the infraspinatus muscle were most elongated in 60° of glenohumeral joint elevation (simulating 90° humerothoracic elevation) and internal rotation, similar to the sleeper stretch. In this study, relationship between pretest IR90 and TUB measures using a Pearson correlation coefficient was $r = 0.52$ on the stretch side and $r = 0.36$ on the control side, for an average r value of 0.44. This indicates only a weak to moderate relationship between the 2 measures and suggests that they are capturing different factors related to internal rotation ROM. Similar to differential findings for the anterior-superior and anterior-inferior capsule based on arm elevation,²⁴ we speculate that the posterior-inferior and posterior-superior aspects of the capsule and rotator cuff muscles are stressed differently based on humeral elevation, therefore require different measures to assess their length and different stretch procedures to induce ROM changes.

One limitation to our study was the use of asymptomatic students rather than throwing athletes or a symptomatic clinical population seeking medical

care. Based on our reliability data, a 90% confidence interval for the IR90 SEM was computed to be $\pm 8.1^\circ$; therefore, we considered a 10° asymmetry a meaningful difference. The average between-side difference in our experimental subjects was almost 14° . We could not say with any certainty whether the side with lesser motion was lacking flexibility or if the side with greater motion was showing excessive flexibility. At pretest, the average IR90 for control subjects was 52.5° compared to an average of 47.4° and 61.1° in the less mobile and more mobile sides, respectively, in the 30 experimental subjects. Selection of the less mobile side for stretching was based on the perceived greater opportunity for improvement of ROM, which was the intent of the 2 stretching procedures. Tyler et al²⁵ found IR90 differences between control subjects and subjects with dominant-side impingement of about 9° on the dominant side and 7° on the nondominant side.²⁵ These differences were less if the impingement symptoms were in the nondominant shoulder. They also reported an average side-to-side difference of about 22° in subjects with dominant side impingement, compared to only a 5° difference between sides in subjects with nondominant side impingement. Myers et al²⁰ found an average between-side difference in shoulder internal rotation of 11° in asymptomatic throwers, but an average 20° difference between sides in throwers with symptomatic internal impingement. Therefore, the differences between sides in our experimental subjects seemed to be somewhere between normal asymmetry found in throwers and asymmetry found in subjects with shoulder injury.

A unilateral lack of shoulder internal rotation ROM has been found previously in throwing athletes and patients seeking care for shoulder impingement syndrome.^{1,4,8,16,17,26} In the current study, out of 54 subjects, 50 reported being athletically active or exercising regularly, but only 11 were engaged in overhead sports. Because stretching is a common preventative measure, particularly in athletes, we believe our sample reflects a relevant

group for whom these stretching exercises could be indicated. Several authors have suggested that glenohumeral joint posterior capsule tightness, as demonstrated by a lack of shoulder internal rotation, may produce superior translation of the humeral head and therefore predispose to subacromial impingement.^{7,13,14,31} We believe the changes in ROM we found can be logically attributed to changes in the posterior glenohumeral joint capsule, periarticular tissue, and posterior cuff muscles. It is difficult to judge whether high-level throwing athletes or a symptomatic patient sample would respond similarly. High-level throwing athletes may have bony changes, such as excessive humeral retroversion, that may limit a response to a stretching intervention.^{9,21,22} Symptomatic patients may be limited primarily by pain rather than shortened periarticular tissue and therefore could respond more dramatically if pain subsided concurrent with a stretching program. Alternatively, pain could prevent adequate end range stretching and therefore limit the effect of the stretch on periarticular tissue and ROM.

Because we did not allow scapular substitution with the IR90 measure, changes in ROM must be secondary to changes in tissues crossing the glenohumeral joint. Both the posterior joint capsule and the posterior rotator cuff muscles are oriented such that they would limit IR90. In this study, it is not possible to determine which of these tissues, or if both, are responsible for the initial difference and subsequent gains in motion. Both muscles and periarticular connective tissues allow length changes with adequate tensile stress¹⁸ and both are stressed with the stretching procedures used in this study. Increased IR90 motion has been noted following surgical release of the posterior capsule, which implies this may be the primary source of limitation, at least in patients who require surgical release.^{23,27}

To determine the effect of gender and hand dominance on response to stretching, we secondarily performed an inde-

pendent *t* test comparing IR90 changes in males versus females in the stretching groups and found no differences based on gender ($P = .22$). Similarly we performed an independent *t* test comparing IR90 changes between those who stretched the dominant side (arm dominance determined by self-report on an intake questionnaire) compared with those who stretched the nondominant side. Again, no differences were found based on which side was stretched ($P = .90$).

A limitation of this work is the lack of any long-term follow-up. It seems unlikely that the changes induced would remain without some ongoing end range tensile stress in the form of stretching. It would be helpful to know if a "maintenance dose" of stretching would be required to maintain the increased motion achieved in 4 weeks and, if so, what dose. Likewise, it would be helpful to know if gains in motion would plateau with a standard, minimal stretching program and, if so, when that plateau would occur. Based on the Physical Stress Theory proposed by Mueller and Maluf,¹⁸ increasing gains would likely require increasing levels of end range stress either by increasing intensity, frequency, or duration. These questions related to the time course of gains in motion and the required dosage of end range stress are clearly important to clinical practice and worthy of further study.

CONCLUSION

BASED ON OUR FINDINGS, THE CROSS-BODY stretch appears to be more effective than no stretching in control subjects without internal rotation asymmetry. While the improvement in internal rotation from the cross-body stretch was greater than from the sleeper stretch and of a magnitude that could be clinically significant, the small sample size likely precluded statistical significance between groups. These findings were in a group of asymptomatic recreational athletes and further study is warranted in higher-level throwing athletes as well as in patients with symptoms. ●

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