Fauls Stretching Routine Produces Acute Gains in Throwing Shoulder Mobility in Collegiate Baseball Players

Eric Sauers, Anna August, and Alison Snyder

Context: Stretching prior to activity or as a rehabilitative intervention may promote increased throwing shoulder range of motion (ROM) in baseball pitchers. Objective: To evaluate the acute effects of Fauls modified passive stretching routine on throwing shoulder mobility in collegiate baseball players. Design: Repeated measures. Setting: Laboratory. Participants: Thirty collegiate baseball players with unimpaired shoulders. Interventions: Fauls modified passive stretching routine was performed on the throwing shoulder of each subject. Outcome Measures: Shoulder complex and passive isolated glenohumeral internal and external rotation ROM were measured with a goniometer, and posterior shoulder tightness was assessed with the Tyler’s test method using a carpenter’s square. Measurements were made bilaterally. Results: The dominant shoulder displayed significant increases in glenohumeral and shoulder complex internal and external rotation ROM and significantly decreased posterior shoulder tightness following the stretching routine. Conclusion: Application of the Fauls modified passive shoulder stretching routine results in acute gains in throwing shoulder mobility of collegiate baseball players. Key Words: flexibility, range of motion, therapy, treatment effectiveness

The throwing shoulder range of motion (ROM) in asymptomatic competitive baseball players consistently displays significant gains in external rotation ROM and decreases in internal rotation ROM when compared to the nonthrowing shoulder.1-8 Currently, it is unclear whether this adaptation in ROM results purely from soft-tissue changes, purely form osseous changes, or from some combination of both. Suggested soft-tissue changes include stretching of the anterior inferior glenohumeral ligament complex resulting in increased external rotation9-11 and contracture of the posterior capsule leading to decreased internal rotation.12-15 Osseous changes include humeral and glenoid retroversion, both of which are thought to contribute to gains in external rotation and concomitant declines in internal rotation.4, 16, 17 Although this adaptation in ROM has been demonstrated repeatedly in the literature, the implications on pathology remain unclear.1,18
The 180° rule suggests that the gains in external rotation ROM measured in the healthy throwing shoulder are equal to the amount of internal rotation ROM lost.\(^1\) However, it is suggested that pathology occurs when the abducted shoulder does not have the full 180° arc of rotational motion.\(^1\) Internal impingement, superior labrum anterior to posterior (SLAP) lesions, and anterior instability are all pathologies thought to be related to alterations in rotational ROM in overhead throwing athletes.\(^1\) Because of the associated injuries, prophylactic stretching of the throwing shoulder is thought necessary to prevent acute injury during throwing and the chronic development of posterior shoulder tightness and loss of internal rotation ROM.\(^6\)  

Numerous studies have demonstrated the effectiveness of various stretching techniques for improving joint ROM;\(^28-32\) however, these studies have primarily focused on the hip, and very few studies have actually examined the effectiveness of specific therapeutic interventions for increasing ROM at the shoulder. Clinicians use a variety of methods to gain and maintain motion in the throwing shoulder;\(^23-27,\) 33, 34 however, limited data exist from which to determine the effectiveness of different stretching interventions for increasing throwing shoulder ROM. Electrotherapy, manual therapy, active exercises, and various forms of passive stretching have all been attempted, but research does not clearly establish one method of treatment as more effective than the others.\(^23-26\)

Of particular interest is the Fauls modified passive shoulder stretching routine, which has been widely used since the 1980s to improve throwing shoulder ROM in baseball athletes for both prevention and rehabilitation.\(^35, 36\) The Fauls routine differs from most stretching protocols that have been studied that typically employ a single stretch technique (static, ballistic, proprioceptive-neuromuscular facilitation) to alter ROM. The Fauls routine is a stretching protocol that combines a mixture of gentle rolling and waving motions with static stretches in a prescribed progression to promote muscular relaxation and increased ROM. The order of stretching is performed to minimize moving the athlete and to allow each stretch technique to flow smoothly into the next. This combination of stretching techniques in a prescribed series aimed at producing global increases in shoulder mobility is unique, and data supporting this type of protocol are lacking. In addition to the unique series of stretches utilized in the Fauls routine, the duration of each stretch recommended is only 3–7 seconds. This stretch duration is shorter than most traditional programs that suggest stretching durations of 15-30 seconds per stretch.\(^30, 37\)

Epidemiological data in collegiate baseball players demonstrate that shoulder injuries, specifically rotator cuff tendonitis, account for a majority of injuries and time lost from the sport and that 69% of shoulder injuries occur in pitchers.\(^38\) Clinically, acute improvements in shoulder ROM prior to throwing may be preventative and reduce injuries incurred during throwing. Specifically, techniques aimed at acutely increasing external and internal rotation ROM prior to throwing may help to reduce strain in the anterior and posterior glenhumeral joint capsule, thereby decreasing injury potential. Currently, the Fauls protocol is widely used to achieve acute gains in shoulder ROM prior to throwing, but data supporting the effectiveness of this unique clinical intervention are lacking. Therefore, the purpose of this study was to determine the acute effects of Fauls modified passive shoulder stretching routine for increasing ROM in the throwing shoulders of collegiate baseball players. We hypothesized that the Fauls modified passive shoulder
A stretching program would effectively improve acute external and internal rotation ROM and reduce posterior shoulder tightness in the throwing shoulder of collegiate baseball players.

**Method**

**Design and Subjects**

An experimental design was used to evaluate thirty male collegiate baseball players (20.2 ± 1.2 years, 184.9 ± 6.1 cm, 84.9 ± 9.2 kg) with no recent history of shoulder or elbow injury or surgery. Subjects reported to the athletic training room where they read and signed an informed consent document approved by the Institutional Review Board for the protection of human subjects. Subjects were then screened for any recent history of shoulder or elbow injury or past history of shoulder or elbow surgery. In addition, subjects were screened to ensure that they had not stretched their shoulders (or had them stretched by someone else), had not received any form of shoulder treatment (heat, ice, ultrasound, etc.), and had not participated in any vigorous upper extremity activity in the last 12 hours. Subjects were asked which arm they used to throw a baseball and this was chosen as their experimental shoulder.

**Interventions**

Pretreatment passive measurements of shoulder mobility for five different measurement variables were obtained in the throwing and nonthrowing shoulder of each subject. The order of testing for shoulder and measurement was randomized, and the investigator was blinded to the measurement values. Immediately following the pretreatment measurements of shoulder mobility, one investigator performed the Fauls modified passive shoulder stretching routine to the experimental (throwing) shoulder. The contralateral nonthrowing shoulder served as an internal control and received no treatment of any kind.

Fauls modified passive shoulder stretching routine (Table 1), as described by Arrigo, incorporates twelve passive stretches performed by a clinician, in series, and is designed specifically to promote muscular relaxation and to increase ROM in the throwing shoulder. The routine requires that shoulder flexion, external rotation, and internal rotation stretches are progressively performed in order to ensure that the inferior, anterior, and posterior aspects of the shoulder are stretched, and several series of circular arm motions are integrated with the stretches. Stretches consist of five repetitions of 3 to 7 seconds each. Each circular arm motion is repeated 5 to 10 times, reversed, and then repeated in the opposite direction. End points for all of the stretches were identified subjectively by the investigator and performed within the range of a “comfortable stretch” subjectively reported by the athlete. The total passive stretching routine takes approximately 10 min to perform. For the purposes of this study, we applied all of the techniques in the order described by Arrigo and listed in Table 1. To ensure uniformity in our intervention methods and to maximize the possibility for producing an acute treatment effect, all stretches were maintained for 7 seconds, and 10 repetitions were performed for all circular motions.
Table 1  Fauls Modified Passive Shoulder Stretching Routine

<table>
<thead>
<tr>
<th>Order of Stretches</th>
<th>Stretch Performed</th>
<th>Stretch Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sidelying</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Shoulder Roll</td>
<td>Clinician rotates athlete’s entire shoulder complex.</td>
</tr>
<tr>
<td>2</td>
<td>Pectoral Stretch</td>
<td>The athlete’s arm is taken into full flexion and the clinician then simultaneously pulls the scapula toward him/herself while also pushing the arm over the athlete’s head.</td>
</tr>
<tr>
<td>3</td>
<td>Extension Stretch</td>
<td>Athlete’s arm is taken into full extension.</td>
</tr>
<tr>
<td>4</td>
<td>Flexion Stretch</td>
<td>Athlete’s arm is taken into full flexion.</td>
</tr>
<tr>
<td>5</td>
<td>Shoulder Circles</td>
<td>Arm in 90° abduction and 90°elbow flexion, clinician gently rotates athlete’s glenohumeral joint.</td>
</tr>
<tr>
<td></td>
<td>Supine</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>The Pump Stretch</td>
<td>Clinician’s forearm under proximal humerus and the shoulder is taken into extreme horizontal abduction.</td>
</tr>
<tr>
<td>7</td>
<td>Shoulder Flexion Stretch</td>
<td>Athlete’s arm is taken into full flexion.</td>
</tr>
<tr>
<td>8</td>
<td>Internal Rotation Stretch</td>
<td>Arm in a position of 90° abduction and 90°elbow flexion, the athlete’s arm is taken into internal rotation.</td>
</tr>
<tr>
<td>9</td>
<td>External Rotation Stretch</td>
<td>Arm in a position of 90° abduction and 90°elbow flexion, the athlete’s arm is taken into external rotation.</td>
</tr>
<tr>
<td>10</td>
<td>Elbow Circles</td>
<td>The clinician supports the athlete’s elbow and gently rotates it in large circles, both directions.</td>
</tr>
<tr>
<td>11</td>
<td>Wrist Circles</td>
<td>The clinician supports the athlete’s wrist and gently rotates it in large circles, both directions.</td>
</tr>
<tr>
<td>12</td>
<td>Arm Waves</td>
<td>The clinician holds the athlete’s hand in both hands and vigorously waves the entire arm up and down.</td>
</tr>
</tbody>
</table>
Outcome Measures

Immediately following the completion of the stretching intervention on the experimental shoulder, posttreatment measures for each of five measurements of shoulder mobility were repeated bilaterally. The following passive ROM measures were obtained to collectively describe the construct of shoulder mobility: (1) shoulder complex external rotation, (2) isolated glenohumeral joint external rotation, (3) shoulder complex internal rotation, (4) isolated glenohumeral joint internal rotation, and (5) posterior shoulder tightness. Measurements of shoulder complex and isolated glenohumeral joint motion were taken to determine if the intervention was effective at producing ROM changes at both the shoulder complex globally and the glenohumeral joint specifically. Posterior shoulder tightness was evaluated because of its important role in pathologies such as secondary impingement and SLAP lesions in the throwing shoulder. The order of testing for shoulder and measurement was randomized and the investigator was blinded to the measurement values.

Shoulder Complex Motion. Shoulder complex ROM considers motion achieved collectively from the scapulothoracic articulation and glenohumeral joint. Shoulder complex ROM was measured without stabilizing the scapula using a standard goniometer. Subjects were placed supine on a treatment table with their test arm elevated to 90° of abduction and supported with a towel to ensure neutral horizontal flexion/extension. The investigator then passively moved the humerus into internal rotation with one hand. Upon reaching end range of motion, as evidenced by a firm end feel caused by tension in the major and minor rhomboid muscles and the middle and inferior portions of the trapezius, the measurement was taken. The test was then repeated into external rotation.

Isolated Glenohumeral Joint Motion. Passive isolated glenohumeral joint measures account for ROM achieved purely from the glenohumeral joint without the contribution of scapulothoracic motion. Passive isolated glenohumeral joint internal and external rotation ROM was measured with the scapula stabilized using a standard goniometer. Subjects were placed supine on a treatment table with their test arm elevated to 90° of abduction and supported with a towel to ensure neutral horizontal flexion/extension. The investigator then passively moved the humerus into internal rotation with one hand and stabilized the scapula with their other hand. Upon reaching a capsular end-feel, as evidenced by initiation of scapular movement and a firm restriction of humeral motion, the measurement was taken using the goniometer by a second investigator. The test was then repeated into external rotation.

Posterior Shoulder Tightness. A clinical measurement method has been shown to be a reliable and valid measure of posterior shoulder tightness and is correlated to diminished internal rotation in baseball players. With the subject in the supine position the arm is placed in 90° of abduction with the humerus in neutral rotation. The scapula is stabilized in the fully retracted position, and the humerus is then passively moved into horizontal adduction. The humerus is lowered until motion is ceased or rotation occurs and then a measurement is made from the treatment...
table to the medial epicondyle. An increase in the measured distance indicates a less flexible posterior shoulder.

**Statistics**

A separate repeated measures analyses of variance (ANOVA) was performed for each of the following dependent variables: (1) shoulder complex external rotation range of motion (SCER), (2) passive isolated glenohumeral joint external rotation range of motion (GHER), (3) shoulder complex internal rotation range of motion (SCIR), (4) passive isolated glenohumeral joint internal rotation range of motion (GHIR), and (5) posterior shoulder tightness. Each analysis consisted of two within-subjects variables: (1) Time (pre- and post-treatment) and (2) Shoulder (throwing and nonthrowing). All data were analyzed using SPSS statistical software (SPSS for Windows, Version 11.5, SPSS, Inc., Chicago, IL). The *a priori* alpha level was set at .05.

**Results**

Descriptive data for shoulder complex external rotation and isolated glenohumeral joint external rotation are provided in Table 2. The repeated measures ANOVA for shoulder complex external rotation revealed a significant Time × Shoulder interaction effect: $F_{1,29} = 24.7, P < .001$. There was also a significant main effect for Time, $F_{1,29} = 36.4, P < .001$, and Shoulder, $F_{1,29} = 16.1, P < .001$.

The repeated measures ANOVA for isolated glenohumeral joint external rotation revealed a significant Time × Shoulder interaction: $F_{1,29} = 26.1, P < .001$. A significant main effect for Time, $F_{1,29} = 22.6, P < .001$ and Shoulder, $F_{1,29} = 19.7, P < .001$ was also observed.

**Table 2  Shoulder Complex External Rotation (SCER) and Passive Isolated Glenohumeral External Rotation (GHER)**

<table>
<thead>
<tr>
<th></th>
<th>Pre-Treatment</th>
<th>Post-Treatment</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SCER</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experimental</td>
<td>105.3 ± 9.0</td>
<td>112.9 ± 11.0</td>
<td>+ 7.6*</td>
</tr>
<tr>
<td>Control</td>
<td>102.6 ± 7.5</td>
<td>102.9 ± 7.1</td>
<td>+ 0.3</td>
</tr>
<tr>
<td>Side-Side Difference</td>
<td>2.7</td>
<td>10.0</td>
<td>-7.3</td>
</tr>
<tr>
<td><strong>GHER</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experimental</td>
<td>78.4 ± 8.6</td>
<td>83.7 ± 10.1</td>
<td>+ 5.3*</td>
</tr>
<tr>
<td>Control</td>
<td>74.8 ± 9.4</td>
<td>75.3 ± 8.9</td>
<td>+ 0.5</td>
</tr>
<tr>
<td>Side-Side Difference</td>
<td>3.6</td>
<td>8.4</td>
<td>- 4.8</td>
</tr>
</tbody>
</table>

All measures are group means in degrees ± standard deviations. *Indicates statistically significant at $P < .05$. 

Fauls Shoulder Stretching Increases Mobility  33
Descriptive data for shoulder complex internal rotation and isolated glenohumeral joint internal rotation are provided in Table 3. The repeated measures ANOVA for shoulder complex internal rotation revealed a significant Time × Shoulder interaction: $F_{1,29} = 53.7, P < .001$. A significant within-subjects main effect for Time ($P < .001$) was observed. No statistically significant within-subjects main effect for Shoulder was observed ($P = .157$).

The repeated measures ANOVA for isolated glenohumeral joint internal rotation revealed a significant Time × Shoulder interaction: $F_{1,29} = 21.5, P < .001$. Significant within-subjects main effects for Time ($F_{1,29} = 32.5, P < .001$) and Shoulder ($F_{1,29} = 15.1, P = .001$) were also observed.

Descriptive data for posterior shoulder tightness are provided in Table 4. The repeated measures ANOVA for posterior shoulder tightness revealed a statistically significant Time × Shoulder interaction: $F_{1,29} = 26.6, P < .001$. A significant within-subjects main effect for Time ($F_{1,29} = 38.7, P < .001$) was present, but there was no statistically significant within-subjects main effect for Shoulder: $F_{1,29} = 1.2, P = .290$.

Table 3  Shoulder Complex Internal Rotation (SCIR) and Glenohumeral Internal Rotation (GHIR)

<table>
<thead>
<tr>
<th></th>
<th>Pre-Treatment</th>
<th>Post-Treatment</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SCIR</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experimental</td>
<td>87.5 ± 9.0</td>
<td>96.7 ± 9.5</td>
<td>+ 9.2*</td>
</tr>
<tr>
<td>Control</td>
<td>94.1 ± 9.3</td>
<td>94.8 ± 8.1</td>
<td>+ 0.7</td>
</tr>
<tr>
<td>Side-Side Difference</td>
<td>6.6</td>
<td>1.9</td>
<td>- 4.7</td>
</tr>
<tr>
<td><strong>GHIR</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experimental</td>
<td>49.4 ± 11.6</td>
<td>55.8 ± 11.7</td>
<td>+ 6.4*</td>
</tr>
<tr>
<td>Control</td>
<td>56.4 ± 13.9</td>
<td>57.9 ± 13.5</td>
<td>+ 1.5</td>
</tr>
<tr>
<td>Side-Side Difference</td>
<td>7.0</td>
<td>2.1</td>
<td>- 4.9</td>
</tr>
</tbody>
</table>

All measures are group means in degrees ± standard deviations. *Indicates statistically significant at $P < .05$.

Table 4  Posterior Shoulder Tightness (PST) Measurements

<table>
<thead>
<tr>
<th></th>
<th>Pre-Treatment</th>
<th>Post-Treatment</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PST</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experimental</td>
<td>37.8 ± 1.8</td>
<td>35.8 ± 1.7</td>
<td>- 2.0*</td>
</tr>
<tr>
<td>Control</td>
<td>36.5 ± 1.9</td>
<td>36.4 ± 2.0</td>
<td>- 0.1</td>
</tr>
<tr>
<td>Difference</td>
<td>1.3</td>
<td>0.6</td>
<td>- 0.7</td>
</tr>
</tbody>
</table>

All measures are group means in centimeters (cm) ± standard deviations. *Indicates statistically significant at $P < .05$. 
Comments

These data support our hypothesis that the Fauls modified passive shoulder stretching routine would be effective for producing acute increases in throwing shoulder external and internal rotation ROM and reducing posterior shoulder tightness in collegiate baseball players. These data show that the stretched shoulder displays significant mean gains in both shoulder complex and passive isolated glenohumeral internal and external rotation ROM as well as decreased posterior capsule tightness. These findings are in agreement with other studies investigating the acute effects of static stretching,\textsuperscript{40-43} proprioceptive neuromuscular facilitation (PNF),\textsuperscript{23, 42} ballistic stretching\textsuperscript{41, 43} and joint mobilizations\textsuperscript{23, 44} on joint ROM. In this study, the throwing shoulder gained a total of 16.8° and 11.7° degrees of shoulder complex and isolated glenohumeral rotational arc ROM, respectively. As a result of the stretching routine, the postmeasurements of both shoulder complex and isolated glenohumeral internal rotation ROM and posterior shoulder tightness in the throwing shoulder approached the values of the contralateral nonthrowing shoulder. This finding indicates that the stretching program was effective in balancing the internal rotational ROM between shoulders, which may be beneficial for preventing injuries associated with diminished internal rotation.\textsuperscript{14, 39, 45}

Goldman and Sauers\textsuperscript{23} evaluated the acute effects of PNF internal rotation stretching and posterior joint mobilizations in professional baseball pitchers and position players. Thirty-one subjects were randomly assigned to receive one of two interventions and measures of isolated glenohumeral joint internal rotation, and posterior shoulder tightness identical to those described in this study were taken pre and postintervention. Both treatments were equally effective at producing acute changes in internal rotation ROM and posterior shoulder tightness. The experimental shoulder for both treatment groups exhibited a significantly greater average increase in internal rotation of 7.4° following intervention compared to the control shoulder that changed < 1° from pre to postintervention. The experimental shoulder for both treatment groups exhibited a significantly greater decrease in posterior shoulder tightness following intervention (2.8 cm) compared to the control shoulder (1.3 cm). The magnitude of changes observed for internal rotation and posterior shoulder tightness are similar to those found in our study (Tables 3 & 4). Therefore, it appears that multiple techniques are available to clinicians for producing acute gains in internal rotation ROM and reducing posterior shoulder tightness. The techniques performed by Goldman and Sauers\textsuperscript{23} were specific manual techniques aimed at stretching the posterior capsule and rotator cuff that would be expected to produce meaningful gains in ROM. It is interesting to note that the Fauls protocol, despite the fact that it only includes one specific internal rotation stretch that is only held for 7 seconds, produced similar gains to joint mobilization and PNF techniques. This may be due to the circular and waving motions performed during the Fauls protocol producing general muscular relaxation effects contributing to gains in mobility.

McClure et al\textsuperscript{24} performed a randomized controlled trial evaluating the effects of the sleeper stretch and cross-body stretch on shoulder internal rotation with the scapula stabilized. The study population consisted of recreational athletes assigned to either a control group based on ≤ 10° of internal rotation or one of two
experimental treatments groups, both with $\geq 10^\circ$ of internal rotation difference between shoulders. The experimental groups performed self-stretching once daily consisting of 5 repetitions of a 30 second stretch over a 4-week intervention period. The cross-body stretch group demonstrated the greatest gains in motion ($19.9 \pm 11.3^\circ$) compared to the sleeper stretch group ($9.8 \pm 9.5^\circ$) and the control group ($8.8 \pm 8.2^\circ$), which was instructed not to stretch at all.

Although the study by McClure et al.\textsuperscript{24} investigated chronic adaptations to stretching, and the current investigation focused only on acute changes, the data from these studies, combined with the work of Goldman and Sauers\textsuperscript{23} suggest that deficits in internal rotation ROM are responsive to therapeutic interventions. This clearly indicates that soft-tissue changes are at least partly responsible for dominant shoulder internal rotation deficit and that these changes are not 100% osseous, as suggested by a number of recent studies.\textsuperscript{4, 16, 17} If, as the stretching data suggest, the observed changes in shoulder ROM are at least partly attributed to soft-tissue changes, then clinicians should be confident in their ability to effectively improve ROM as the result of manual stretching. If however, these ROM changes were 100% osseous, manual clinical interventions would have little hope for success and the only options for addressing pathology attributed to ROM alterations would involve surgery, such as de-rotational osteotomies.\textsuperscript{46}

Decicco et al.\textsuperscript{25} determined that a six-week PNF stretching regime effectively increased external rotation ROM in the throwing shoulders of healthy, recreational overhand throwing athletes. No assessment of internal rotation ROM was made in this study. Average gains of about $13^\circ$ of external rotation were noted following the program, which is a magnitude of change similar to that reported by McClure et al.\textsuperscript{24} for internal rotation in their cross-body stretching group ($19.9 \pm 11.3^\circ$). These findings are much greater than those observed in the current study and indicate that long-term stretching programs are capable of even greater increases in ROM than those observed immediately post stretching.

Despite the observed effectiveness in increasing ROM, the exact physiological mechanisms for acute adaptations to joint ROM are unclear.\textsuperscript{47} Short-term adaptations are thought to be the result of the viscoelastic property of the muscle-tendon unit and stretch tolerance as opposed to alterations with the stretch reflex or structural remodeling. Muscle is considered an active inhibitor of joint ROM due to the interaction of myosin and actin and the stretch reflex.\textsuperscript{48} However, it is reported that during muscle stretch, low level muscle activity is present and does not prevent improvements in ROM.\textsuperscript{49, 50} In addition, under stretch conditions both deinnervated and innervated muscle exhibit similar tensile forces and absorbed energy, providing further evidence that ROM is not inhibited by the stretch reflex.\textsuperscript{51} Similarly, it is unlikely that a one-time stretching program would significantly alter the length of the muscle-tendon unit or the capsular tissues of the shoulder as tissue remodeling would take sustained intervention.\textsuperscript{52}

It is suggested, however, that the viscoelastic nature of muscle and tendon as well as stretch tolerance may be responsible for joint ROM increases following acute stretching.\textsuperscript{41, 43, 47, 51} As viscoelastic tissues, the muscle-tendon unit exhibits the physical properties of stress relaxation,\textsuperscript{48, 51, 53} creep,\textsuperscript{48, 51, 54} hysteresis,\textsuperscript{48, 51, 55} and strain-rate dependence,\textsuperscript{51} which partially explains the increase in muscle flexibility and joint ROM observed following stretching exercise. Viscoelastic alterations are
considered to be acute and stretch tolerance, or the ability to withstand greater strain, is likely responsible for further improvements in ROM. In this study, it seems likely that the rotational ROM increases were due to a combination of the viscoelastic nature of the muscle-tendon unit and stretch tolerance as opposed to overcoming the stretch reflex or structural remodeling. Regardless of the mechanism, an acute elongation of the structures surrounding the joint may reduce strain in those structures and reduce the potential for acute soft-tissue injury.24, 25, 29, 30, 32, 55-57

Although there are acute benefits to stretching, long-term adaptations in the joint and muscles may also be desired. Investigations into ROM changes following long-term static stretching,30-32, 55-57 PNF,29, 57 and ballistic stretching55, 56 programs in the upper and lower extremities have reported sustained ROM improvements. Therefore, it seems possible that the Fauls stretching program could produce similar long-term ROM gains, if utilized over time, which may help to attenuate the decreased ROM arc often associated with shoulder injuries. Sustained ROM improvements as a result of stretching exercise may indicate a remodeling of the tissues surrounding the joint. However, future studies need to investigate this issue.

One difficulty in comparing stretching studies is that the research protocols and stretching techniques frequently differ. In general, the Fauls stretching program aligns more closely with traditional static stretching than either PNF or ballistic stretching because it incorporates repetitive sustained, or static, stretches. Several series of circular arm motions are also included in the protocol. Since most research focuses on stretching in one ROM (ie, flexion, internal rotation, etc.), it is difficult to determine whether the addition of multiple ranges of motion and rotary movements in the Fauls program produces superior improvements in motion about a joint compared to other stretching techniques. Regardless, the ability of this stretching protocol to produce acute, preactivity gains in external rotation and to return throwing shoulder internal rotation ROM back to the level of the nonthrowing shoulder is clinically significant. As a result of this stretching program, it is assumed that baseball athletes will have the ability to use the additional ROM throughout their training session. The injury prevention potential of this program is unknown, but it is speculated that if acute shoulder rotational ROM gains can be achieved prior to participation, then the throwing shoulder would be at decreased risk for acceleration and deceleration injuries.

In conclusion, the Fauls modified passive stretching protocol was effective in increasing both internal and external rotation ROM and decreasing posterior shoulder tightness in the throwing shoulder of collegiate baseball players. Future research should address the long-term ROM and capsular adaptations to this sustained stretching program, as, together, the knowledge may be used to identify injury prevention programs for overhead-throwing athletes.

References


