The Immediate Effects of Soft Tissue Mobilization With Proprioceptive Neuromuscular Facilitation on Glenohumeral External Rotation and Overhead Reach

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Study Design: Randomized controlled 2-group, pretest-posttest, multivariate study of patients with shoulder musculoskeletal disorders.

Objectives: The purpose of this study was to evaluate the immediate effect of soft tissue mobilization (STM) with proprioceptive neuromuscular facilitation (PNF) to increase glenohumeral external rotation at 45° of shoulder abduction and overhead reach.

Background: It is postulated that limitation in glenohumeral external rotation, when measured at 45° of shoulder abduction, represents subscapularis muscle flexibility deficits and is associated with the inability to fully reach overhead. No research, however, is available to demonstrate whether intervention strategies intended to improve subscapularis flexibility and glenohumeral external rotation range of motion at 45° of shoulder abduction will improve a patient's ability to reach overhead.

Methods and Measures: Twenty patients (10 males, 10 females; age range, 21-83 years) with limited glenohumeral external rotation and overhead reach of 1 year duration or less served as subjects. The subjects were randomly assigned to a treatment group, which consisted of soft tissue mobilization to the subscapularis and proprioceptive neuromuscular facilitation to the shoulder rotators, or a control group. Goniometric measurements of glenohumeral external rotation at 45° abduction and overhead reach were taken preintervention and immediately postintervention for the treatment group or at prerest and postrest periods for the control group.

Results: The treatment group improved by a mean of 16.4° (95% confidence interval [CI], 12.5°-20.3°) of glenohumeral external rotation, as compared to less than a 1° gain (95% CI, −0.2°-2.0°) in the control group (P < .0005). Overhead reach in the treatment group improved by a mean of 9.6 cm (95% CI, 5.2-14.0 cm) in comparison to a mean gain of 2.4 cm (95% CI, −0.8-5.6 cm) for the control group (P = .009).

Conclusion: These findings suggest that a single intervention session of STM and PNF was effective for producing immediate improvements in glenohumeral external rotation and overhead reach in patients with shoulder disorders. J Orthop Sports Phys Ther 2003;33:713-718.

Key Words: manual therapy, proprioceptive neuromuscular facilitation, range of motion, shoulder, subscapularis

in the rehabilitation of patients with shoulder impairments, regaining adequate glenohumeral external rotation is believed to be essential for restoring the ability to reach overhead. Identification of the structure, or structures, limiting glenohumeral external rotation may assist in planning the appropriate intervention for these patients. The common limiters of glenohumeral external rotation are the glenohumeral capsule and the shoulder internal rotators. The investigators of this study have observed that glenohumeral external rotation is commonly more limited in the lower ranges of abduction, such as at 45° of abduction, when compared to the higher ranges of abduction, such as at 90° of abduction. Cadaver studies and outcomes of subscapular surgical releases suggest that subscapularis muscle flexibility deficits are responsible for glenohumeral external rotation limitations in the lower ranges of abduction. A contrasting clinical and cadaver finding is where glenohumeral external rotation becomes more limited as the humerus moves toward 90° of abduction, suggestive of glen-
Glenohumeral capsular restrictions. Thus, a patient who has greater limitation of glenohumeral external rotation at 45° of abduction, when compared to the available external rotation at 90° of abduction, may have a subscapularis muscle flexibility deficit rather than a glenohumeral capsular restriction. In this instance, an appropriate intervention may include procedures purported to improve muscle extensibility, such as soft tissue mobilization (STM) and proprioceptive neuromuscular facilitation (PNF). This is in contrast to patients presumed to have a capsular restriction who would likely benefit from interventions that are intended to improve joint accessory motions, such as joint mobilization.

In this study, the investigators will presume that a patient who has less glenohumeral external rotation at 45° of abduction, when compared to the amount of external rotation at 90° of abduction, has a subscapularis muscle flexibility deficit. The investigators of this study hypothesized that STM and PNF procedures applied to the subscapularis would increase the available glenohumeral external rotation at 45° of abduction and would improve the ability to reach overhead.

Soft tissue mobilization is the application of specific and progressive manual forces with the intent of promoting changes in the myofascia, allowing for elongation of shortened structures. STM procedures are often combined with PNF procedures because they are both used to effect changes in myofascial length. Contract-relax PNF procedures have been shown to be effective in increasing range of motion (ROM). It has been proposed that PNF methods, particularly those involving reciprocal activation of the agonist and antagonist to the desired motion, provide the greatest potential for muscle lengthening. The immediate effects of combining STM and PNF interventions were demonstrated in a previous study using healthy subjects, where improvements were made in hip ROM utilizing midrange STM combined with PNF. In a case series of 3 patients with shoulder impingement syndrome and accompanying limitations in shoulder abduction, myofascial massage and stretching of the subscapularis resulted in a return to full painless function in all 3 patients.

However, the immediate effects of STM and PNF to patients with shoulder motion limitations have not been examined in a randomized, controlled trial. Thus, the purpose of this study is to evaluate whether STM to the subscapularis combined with PNF procedures intended to increase shoulder external rotation will produce an immediate improvement in (1) glenohumeral external rotation when measured at 45° of abduction, and (2) overhead reach in subjects with shoulder pathology.

**METHODS**

**Subjects**

Twenty subjects (10 males, 10 females) between the ages of 21 and 83 years, with shoulder pathology of 1 year or less, participated in the study. Subjects were patients referred to an outpatient physical therapy clinic for evaluation and interventions for the functional losses related to their shoulder pathology. Subjects were included in the study if they exhibited limitations in overhead reach as well as glenohumeral external rotation when measured at 45° of shoulder abduction. Limitations in overhead reach were operationally defined as inability to walk fingers up the side of a wall as high as the opposite (nonpathological) side. A subject was defined as having limitations in glenohumeral external rotation at 45° abduction if the amount of external rotation was less than 90° and the amount of external rotation increased when the limb was moved to 90° of abduction. Subjects whose available glenohumeral external rotation decreased as the humerus was abducted to 90° were presumed to have capsular restrictions and thus excluded from the study. Patients were also excluded if they had a surgical procedure to the shoulder less than 4 weeks prior to study enrollment, total shoulder arthroplasty, reflex sympathetic dystrophy and related syndromes, or rheumatoid arthritis. After they signed an informed consent to participate in the study, subjects were randomly assigned to a treatment or control group. A predetermined schedule of random assignments to treatment and control groups was followed. To develop the schedule, a random number table was used to assign the 20 enrollment numbers in blocks of 4. The protocol for this study was approved by the Institutional Review Board of Loma Linda University.

**Procedures**

Measurements of external rotation and overhead reach were made on all subjects before and after receiving either the experimental or control intervention. The same physical therapist investigator (D.S.), who was blinded to the group assignment, performed all measurements.

Glenohumeral external rotation was measured with the subjects lying supine on a treatment table with a pillow under their knees. Stabilization of the scapula was achieved by depressing the shoulder girdle. Reference lines for abduction were drawn on the skin over the midpoint of the sternum and the anterior aspect of the midline of the humerus. A reference point was also drawn on the skin over the anterior aspect of the acromion. In addition, a reference line was drawn on the skin over the ulnar aspect of the
Measurement of glenohumeral external rotation at 45° of abduction.

Overhead reach was measured with the subjects in standing position facing a wall, with the tips of their toes aligned with a premarked line on the floor 30.5 cm from the wall. The subjects were asked to actively walk their fingers up the wall to reach as far as they could. Overhead reach was measured as the distance in cm from the floor to the tip of the middle finger using a tape measure (Figure 2). To establish intrarater reliability for measuring external rotation and overhead reach, the measurements taken before and after the control intervention on the 10 control subjects in the study were analyzed. The intraclass correlation (ICC3,1) for the external rotation repeated measures was 0.96 (95% confidence interval [CI], 0.84-0.99). The ICC3,1 scores for the overhead reach was 0.97 (95% CI, 0.89-0.99).

Subjects in the treatment group received STM to the subscapularis, followed by PNF procedures. The subjects were positioned with the humerus abducted to approximately 45°. With the elbow flexed to 90°, the humerus was externally rotated to a midrange position, typically about 20° to 25° of external rotation. The subscapularis was palpated in the axilla to identify areas of myofascial mobility restrictions, taut bands, or trigger points. Identified restrictions were treated with STM utilizing a combination of sustained manual pressure, and slow deep strokes to the subscapularis myofascia for 7 minutes (Figure 3). The STM was followed by contract-relax PNF to the subscapularis and other glenohumeral medial rotators, beginning in the same position used for the STM. The patients were instructed to perform maximal glenohumeral internal rotation against an opposing, isometric, manual resistance applied by the treating physical therapist for 7 seconds. Afterwards, the patient actively moved the humerus into full available external rotation. This position was main-
FIGURE 4. Proprioceptive neuromuscular facilitation of active shoulder flexion, abduction, and external rotation.

The control subjects lay supine on a treatment table with pillows under their knees and resting their hands on their abdomen for a period of 10 minutes.

Data Analysis

Independent t tests were used to determine whether there were differences of age, height, and days since onset of condition between the treatment and control groups. A chi-square test was used to determine gender difference between the groups. An individual mixed-model ANOVA, with the within-subject factor being time and the between-subject factor being group, was used to test for significant changes in glenohumeral external rotation at 45° abduction and overhead reach. Because ANOVA results showed an interaction between time (premeasurements and postmeasurements) and treatment group for both variables, 1-way ANOVAs were used to test for differences initially and analyze the differences between premeasurements and postmeasurements for both variables. All statistical analyses were tested at the .05 level of significance.

RESULTS

Table 1 provides a summary of the medical diagnoses given to the subjects by their referring physician. The majority of the subjects had shoulder dysfunctions relating to impingement syndrome or had had a rotator cuff repair. Table 2 compares the 2 groups at baseline for age, gender, height, and days since onset of condition. There were 5 males and 5 females in each group. Mean age was 60.8 years and 58.6 years for the treatment and control groups, respectively. The time since onset of the shoulder condition was approximately 3 months for the treatment group and 4 months for the control group. There were no significant differences between groups on any of these variables.

The immediate effects of the STM and PNF treatment procedures were determined by comparing the postintervention gain in glenohumeral external ROM and overhead reach between the 2 groups. The groups were similar at baseline on these variables (Tables 3 and 4). Immediately after the intervention, the treatment group showed a gain of 16.4° of external rotation (95% CI, 12.5°-20.3°), a significantly greater gain than the less than 1° gain (95% CI, −0.2°-2.0°) in the control group (P < .0005). Overhead reach improved by a mean gain of 9.6 cm (95% CI, 5.2-14.0 cm) in comparison to a mean of 2.4 cm (95% CI, −0.8-5.6) for the control group (P = .009). Tables 3 and 4 summarize the treatment and control group results.
The purpose of the study was to determine whether STM and PNF procedures are effective in producing an immediate improvement in glenohumeral external rotation at 45° of abduction and overhead reach in patients with shoulder disorders. The results showed that these procedures were able to produce a mean increase of 9.6 cm in overhead reach immediately following a single intervention session. In addition, depending on the patient's stage of healing and intervention session tolerance, the procedures described in this study could be repeated during the same or subsequent intervention session to further improve the patient's ability to reach overhead. These results provide a useful treatment option where traditional end range stretching may cause discomfort, muscle guarding, or are contraindicated. These results also extend the findings of a previous study, where a combined STM and PNF intervention produced immediate improvements in hip mobility in a healthy population, to patients with shoulder disorders.

A noteworthy finding at the screening for initial inclusion into the research was that all subjects demonstrated greater limitations in glenohumeral external rotation at 45° than at 90° of abduction. It is also noteworthy that none of the subjects in this study received the medical diagnosis of adhesive capsulitis from their physician. Based on biomechanical studies that demonstrate more selective tension of the glenohumeral joint capsular-ligamentous structures than tensioning of the musculature surrounding the shoulder at 90° abduction, restrictions of external rotation at 45° of abduction are potentially caused by primarily muscular restriction rather than joint capsular restrictions. The results of this study suggest that examining the amount of glenohumeral external rotation at 45° of abduction may be useful in guiding a clinician's plan of care for patients with shoulder disorders. For example, initiating procedures intended to address subscapularis muscle flexibility deficits may be the intervention of choice for patients who exhibit less glenohumeral external rotation at 45° of abduction when compared to 90° of abduction. Assessing the comparative differences in external rotation range of motion at varying degrees of abduction on patients following surgical procedures that shorten the subscapularis (e.g., in patients with recurring shoulder dislocation) may further examine the validity of this clinical test.

This study used a single-intervention-session design. The design of the study does not allow for drawing conclusions regarding the effect of the intervention beyond a single visit. The design of this study also does not allow for comparison to a competing intervention program, such as active mobility exercises, passive stretching, or another manual therapy intervention. The possibility exists that any other intervention could have yielded similar or better results. The lack of a competing intervention group of similar duration and intensity is a limitation of the study. Future studies utilizing several repeated intervention sessions and additional outcome measures, such as self-report disability scales, are needed to determine the long-term efficacy of STM and PNF intervention versus a control or comparison group.

### DISCUSSION

**TABLE 3.** Glenohumeral external rotation (ER) range of motion (mean ± SD in degrees) at 45° of abduction before and after a single intervention session.

<table>
<thead>
<tr>
<th>Treatment Group (n = 10)</th>
<th>Control Group (n = 10)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>PreER 41.6 ± 18.6</td>
<td>34.1 ± 16.6</td>
<td>.35*</td>
</tr>
<tr>
<td>PostER 58.0 ± 20.2</td>
<td>35.0 ± 16.9</td>
<td></td>
</tr>
<tr>
<td>Change in ER 16.4 ± 5.5</td>
<td>9.9 ± 1.5</td>
<td>&lt;.0005*</td>
</tr>
</tbody>
</table>

* No statistically significant difference between groups prior to treatment (1-way ANOVA).
†Statistically significant different change in range of motion between groups as a result of treatment (1-way ANOVA).

**TABLE 4.** Comparison of overhead reach (OHR) (mean ± SD in cm) before and after a single intervention session.

<table>
<thead>
<tr>
<th>Treatment Group (n = 10)</th>
<th>Control Group (n = 10)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>PreOHR 178.7 ± 27.5</td>
<td>184.8 ± 23.4</td>
<td>.60*</td>
</tr>
<tr>
<td>PostOHR 188.3 ± 24.9</td>
<td>187.2 ± 24.9</td>
<td></td>
</tr>
<tr>
<td>Change in OHR 9.6 ± 6.2</td>
<td>2.4 ± 4.5</td>
<td>.009†</td>
</tr>
</tbody>
</table>

* No statistically significant difference between groups prior to treatment (1-way ANOVA).
†Statistically significant different change in overhead reach between groups as a result of treatment (1-way ANOVA).

**CONCLUSION**

Soft tissue mobilization of the subscapularis for 7 minutes and 5 repetitions of contract-relax to the shoulder internal rotators, followed by 5 repetitions of PNF facilitating the flexion, abduction, and external rotation diagonal, was found to be effective in gaining glenohumeral external rotation during a single intervention session in patients with shoulder dysfunction. Additionally, patients treated with STM and PNF improved their ability to reach overhead.

### REFERENCES