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RESEARCH STUDY

The Effect of Joint Mobilization as a Component of Comprehensive Treatment for Primary Shoulder Impingement Syndrome

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Primary shoulder impingement syndrome is a common shoulder problem which, if treated ineffectively, can lead to more serious pathology and expensive treatment. This study examined whether subjects receiving joint mobilization and comprehensive treatment (hot packs, active range of motion, physiologic stretching, muscle strengthening, soft tissue mobilization, and patient education) would have improved pain, mobility, and function compared with similar patients receiving comprehensive treatment alone. Subjects were eight men and six women (mean age = 52.9 years) with primary shoulder impingement syndrome (superolateral shoulder pain, decreased active humeral elevation, limited overhead function). Following random assignment to experimental (N = 7) and control groups (N = 7), three blinded evaluators tested 24-hour pain (visual analog scale), pain with subacromial compression test (visual analog scale), active range of motion (goniometry), and function (reaching forward, behind the head, and across the body in an overhead position) before and after nine treatments. One-tailed analyses of covariance (baseline values as covariates) showed that the experimental group had less 24-hour pain and pain with subacromial compression test but no differences in range of motion and function (Mann-Whitney U) compared with controls. The experimental group improved on all variables, while the control group improved only on mobility and function (one-tailed, paired t tests; Wilcoxon matched pairs). Age, side of dominance, duration of symptoms, treatment attendance, exercise quality, and adherence had no effect on the outcomes. Results may be affected by inadequate sample size, minimal capsular tightness, insensitive functional scale, nonspecific motion measurements, position at which mobilization treatment was given, or a strong effect of comprehensive treatment. Mobilization decreased 24-hour pain and pain with subacromial compression test in patients with primary shoulder impingement syndrome, but larger replication studies are needed to assess more clearly mobilization's influence on motion and function.

Key Words: *shoulder, impingement, joint mobilization*

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Primary shoulder impingement syndrome can occur in nearly anyone who repeatedly or forcefully uses the upper extremity in an elevated position (21). If neglected or treated ineffectively, more severe and debilitating shoulder pathology could develop (22,39,40).

In primary shoulder impingement syndrome, excessive compression occurs at the subacromial joint as a result of either structural or mechanical factors (15). The structural factors include morphological changes in anatomical structures of the subacromial joint. The mechanical factors consist of capsular tightness, humeral head depressor weakness, or subacromial crowding (35). Physical therapy can do little to affect the structural factors but can potentially affect the mechanical factors.

Capsular tightness appears to be a common mechanical problem in primary impingement syndrome and has been reported to occur at the posterior (61), anterior (13), and inferior (8,20) portions of the capsule. Individuals who avoid painful overhead activity or who are subject to motion imbalances as a result of their work or sport can develop capsular tightness (11). During the period of antalgic avoidance or unbalanced movement, capsular connective tissue can lose the ability to lengthen due to decreased critical fiber distance and abnormal collagen fiber cross-linking. As a result of abnormal orientation between fibers, their ability to glide is impaired, leading to joint stiffness (1). Capsular tightness and consequent restricted joint mobility can prevent opposite direction humeral head glide (34), leading to an earlier onset or greater degree of subacromial compression and painful or limited function, particularly in elevated planes of movement (35).

As the understanding of the mechanical factors in primary shoulder impingement syndrome has grown, treatment has evolved accordingly.

Currently, treatment generally consists of a comprehensive four-fold approach: *1)* various heat, cold, and electrical modalities and pain-free exercises designed to reduce subacromial inflammation and crowding (4,23,66), *2)* rotator cuff strengthening to reduce humeral head depressor weakness (31,64), *3)* capsular stretching exercises designed to reduce capsular tightness (20,56), and *4)* patient education to ensure postural and biomechanical balance as well as scapular symmetry (16,62).

Patient education, specifically related to posture and work or sport biomechanics, is essential in the complete treatment of primary shoulder impingement syndrome. Although postural imbalance, particularly scapulothoracic dysfunction, has been implicated as an etiologic factor in secondary impingement syndrome (26,35), postural imbalance can also occur as a secondary development in primary shoulder impingement syndrome. Scapular asymmetry and its role in impingement has been widely reported by investigators of upper extremity pathology (16,55,62). Warner et al (61) determined that 57% of their subjects with impingement syndrome demonstrated static scapular asymmetry, and all demonstrated dynamic scapular imbalance. Additionally, the position of the humerus at rest can affect the healing process of patients with primary shoulder impingement syndrome. The work of Rathbun and Macnab (51) illustrated the deleterious "wringing out" effect on rotator cuff tendon vascularity with an adducted dependent posture of the humerus.

To restore capsular extensibility, tensile forces need to be applied over time, allowing capsular tissue to remodel in an elongated position (3,63). To impart this force and to achieve this effect, joint mobilization (34) and physiologic stretching (45) have been recommended. Joint mobilization may be preferred because it provides precise stretch to a specific part of the capsule and can be performed with less pain, reduced load on other periarticular structures, and less compressive force on articular structures (24,32) compared with physiologic stretching. Investigators have suggested that joint mobilization may have an important role in restoring capsular extensibility in primary shoulder impingement syndrome (20,61) by preventing or stretching abnormal collagen cross-linkage (65), rupturing adhesions (12), reducing edema (50), or reducing pain (67).

Few controlled investigations have examined the efficacy of joint mobilization, and those that have been performed have produced conflicting results. Investigators studying the effect of mobilization on dog carpi and human metacarpophalangeal joints have demonstrated increased motion over control subjects (43,50), while others who studied the effect on human shoulders have not found changes in mobility (7,41).

Based on the conflicting results of these studies, the therapeutic effect of joint mobilization remains unclear. In spite of the presumed presence of capsular dysfunction in primary shoulder impingement syndrome, there have been no controlled studies evaluating the effect of joint mobilization on subjects with this diagnosis. Physical therapists frequently treat primary shoulder impingement syndrome and routinely administer joint mobilization with the intent of restoring capsular mobility without evidence that mobilization is a necessary addition to a treatment regimen of hot packs, active range of motion, physiologic stretching, muscle strengthening exercises, soft tissue mobilization, and patient education.

The purpose of this study was to evaluate whether joint mobilization provided any added effectiveness over conventional treatment in reducing pain and improving active motion and function in patients with primary shoulder impingement syndrome. The specific hypotheses were that patients diagnosed with primary shoulder impingement syndrome, treated with manual joint mobilization combined with hot packs, active range of motion, physiologic stretching, muscle strengthening exercises, soft tissue mobilization, and patient education, would experience *1)* less pain intensity over a 24-hour period, *2)* less pain intensity upon subacromial compression testing, *3)* greater active range of motion, and *4)* greater ability to reach overhead in front, behind the head, and across the body in an overhead position compared with patients with the same diagnosis treated with similar comprehensive treatment without joint mobilization.

METHOD

Study Design

A pretest/posttest control group design was used. Subjects were randomly assigned to either the experimental (mobilization) or the control (no mobilization) group. Both the subject and examiner were blinded to group assignment. Treatment was administered by the principal investigator.

Subjects

Eight male and six female patients diagnosed by their referring physicians with primary shoulder impingement syndrome were enrolled (Table 1). All subjects signed consent forms approved by the University Institutional Review Board. The accurate diagnosis of subjects with primary impingement syndrome was critical for this study. If impingement occurs due to a secondary phenomenon or it is confused with signs and symptoms from some other extrinsic problem, then the treatment strategy becomes significantly different. Subject selection criteria included pain about the superolateral shoulder region and one or more of the following findings: active range of motion deficits in humeral elevation (35), painful subacromial compression

Variable	Control Group ($N = 7$)		Experimental Group ($N = 7$)		t	p
	$\bar{X}$	SD	$\bar{X}$	SD		
Age (years)	50.7	16.5	55.0	10.2	−.59	NS
Height (m)	1.7	0.1	1.7	0.1	−.64	NS
Weight (kg)	76.0	15.8	79.2	16.4	.38	NS
24-hour pain (mm)	46.22	20.51	47.80	27.89	.12	NS
Subacromial compression test pain (mm)	54.53	30.21	48.56	24.21	.41	NS
Flexion (degrees)	132.86	33.89	105.43	36.03	−1.47	NS
Abduction (degrees)	110.86	29.89	95.00	28.87	−1.01	NS
Elevation (degrees)	133.71	21.95	108.57	30.78	−1.76	NS
External rotation (degrees)	71.14	16.90	57.43	26.43	−1.16	NS
Internal rotation (degrees)	37.71	18.66	29.71	9.34	−1.01	NS

NS = Not significant.

TABLE 1. *Means, standard deviations, and t tests at baseline for descriptive and dependent variables.*

(19,38), and limited functional movement patterns in an elevated position. An upper quadrant clearing exam (14) performed by the principal investigator ruled out cervical, elbow, wrist, and hand involvement. Differential examination performed by the principal investigator, aided by information provided by the referring physician, ruled out shoulder instability (14,22), primary scapulothoracic dysfunction (26), stage II and III adhesive capsulitis (10), third-degree musculotendinous tears (28, 59), advanced acromioclavicular joint disease (38), advanced calcific tendinitis or bursitis (19), severe degenerative bony or ligamentous changes (17), neurological involvement (69), and unstable fracture of the humerus, scapula, or clavicle. In some cases, clinical tests were supplemented with information from physician-interpreted radiographic, magnetic resonance imaging, and computerized tomography scan studies. Based on the stated selection process, subjects were enrolled as having primary shoulder impingement syndrome.

Procedure

Following random assignment (experimental group: $N = 7$, control group: $N = 7$), examination before and after treatment was performed by the same examiner. Three experienced physical therapists (female, 47 years old, 10 years of experience; female, 41 years old, 19 years of experience; and male, 30 years old, 5 years of experience) performed the examinations. The principal investigator, also a physical therapist (male, 40 years old, 16 years of experience), performed all treatments. Each examiner was trained by and practiced with the principal investigator.

The effect of treatment was based on 10 dependent variables measured at the beginning and the end of the treatment period. Maximum pain intensity over the preceding 24-hour period and pain intensity with subacromial compression were rated by the subject on a 100-mm horizontal visual analog scale with the endpoints identified as "no pain" and "worst pain imaginable". This scale is reported to be a reliable and valid measurement of pain (48,52).

The impingement sign, originally described by Neer (38), is well recognized and, although it remains unstudied, investigators report that this sign is a key indicator of impingement syndrome (47). The subacromial compression test designed for this study was modified from the impingement sign described by Neer (38) and modified by Hawkins and Abrams (19). The test was performed with the subject in an erect posture. As Neer originally described, the evaluator positioned one hand over the acromion of the scapula for stabilization. The other hand was positioned on the ulnar proximal forearm. The humerus was passively elevated into the stabilized acromion. In an attempt to standardize the testing procedure, a variance to Neer's description was instituted by performing the movement in the scapular plane (25) with the elbow flexed 90° and the forearm in a relaxed, palm down position. Once elevated, the arm was moved anteriorly (as described by Hawkins) and posteriorly in a horizontal plane, attempting to compress all regions of the subacromial joint and thereby reproduce the subject's pain (Figure 1). Three repeated measurements were performed as tolerated. Following each test, the subject was asked to rate his or her pain using the visual analog scale.

Because no estimates of reliability on the subacromial compression test were available in the literature, intrarater reliability was examined as part of this study. Thirteen of 14 subjects tolerated three repeated maneuvers and one additional subject failed to follow the test procedure; therefore, 12 subjects' data were used for reliability estimates. The three visual

FIGURE 1. *Subacromial compression test. × = fixation or stabilization; ⇒ = direction of glide with force; and ⇔ = direction of movement of body part. (Adapted from Foley et al (14), with permission).*

analog scales were analyzed with an analysis of variance with repeated measures; the pretreatment reliability was indicated by an ICC (3,1) (57) of 0.70, and the posttreatment reliability was 0.59. The pretreatment test appeared to create a reactive response among the subjects. Ten of the 14 subjects experienced more pain on the second trial; half of those had the same or increased pain on the third trial. Because the visual analog scale has been shown to be reliable, the variability in scores appears to be due to the test reactivity, and the first of three trials was used for subsequent analysis.

Active range of motion of shoulder flexion, shoulder abduction, scapular plane elevation, shoulder internal rotation, and shoulder external rotation were measured with a large clear plastic universal goniometer (Smith, Nephew & Roylan, Inc., Germantown, WI) that was calibrated against known angles (30°, 45°, 90°, 150°, 180°) (60). Goniometry is reported to be both reliable (53) and valid (29) for the glenohumeral joint. A standard procedure for measurement was followed (42). End point criteria, established by Andrews and Bohanon (2), were used.

Overhead function was assessed through performance of three activities that maximally stress and potentially incite an irritable subacromial joint region as the joint moves into and through its closed pack position. The examiner first demonstrated the activity. The subject then practiced the skill with the uninvolved arm as the examiner assessed the quality and quantity of "normal" movement. Using the involved arm, subjects were asked to *1)* reach behind their heads and touch the external occipital protuberance with the long finger, with the back and arm against the wall, *2)* reach across and around the upper body to the lowest cervical or thoracic spinous process that they could reach with the long finger, and *3)* using the long finger, touch a mark on the wall that required 135° of shoulder flexion. For the third activity, a mark was made for each subject on the wall and on a floor ruler representing the tip of the ipsilateral shoe. The subject then positioned the involved side shoe appropriately and attempted to reach the mark on the wall with the involved arm.

Functional skills were graded on a 3-point scale by the examiner: can do/can do in spite of pain/cannot do. A grade of "can do" required the quality and quantity of movement similar to the uninvolved arm with no evidence of pain. A second grade of "can do in spite of pain" required the quantity of movement demonstrated by the uninvolved arm, although the quality may demonstrate antalgic behavior. No normative data are available for this scale; test-retest reliability was evaluated as part of this study. Up to three repeated measurements were performed as tolerated. The mode of the three trials was used for analysis. The Kappa coefficient (9) was calculated for each pair of trials of the three functional skills. Thirteen subjects completed three trials at pretreatment and posttreatment. The mean pretreatment/posttreatment values of the Kappa coefficient were 0.76 and 0.74 for the external occipital protuberance test, 0.74 and 0.84 for the spinous process test, and 0.92 and 0.90 for the 135° reach. All six values were of "substantial agreement" and three of the values were of "almost perfect strength of agreement" (30).

All treatments were delivered by the same physical therapist (principal investigator). Based on the work of previous investigators (7,41,43,50) and the experience of the principal investigator, a schedule of three times per week for 3 weeks was established. All subjects received hot packs, active range of motion, physiologic stretching and muscle strengthening exercises, soft tissue mobilization, and patient education. In the supine position, hot packs were administered for 15 minutes with placement covering the posterior, superior, and anterior aspects of the shoulder. Exercises were performed for approximately 45–60 minutes. Active range of motion exercises consisted of pendulum exercise and postural correction performed within pain-free range. Physiologic stretching consisted of cane-assisted flexion and external rotation, towel-assisted internal rotation, and noninvolved arm-assisted horizontal adduction, performed within tolerable limits,

The principal investigator applied oscillatory pressure of two to three oscillations per second.

preferably to the end of available range. Muscle strengthening exercises included chair press and internal and external rotation isometrics. The postural correction and chair press exercise focused on correction of postural imbalance, including scapular asymmetry. All other exercises were designed to restore synchronous scapulohumeral rhythm (45), either through stretching to restore glenohumeral capsular mobility or strengthening to restore strength and timing of the rotator cuff and parascapular musculature. Although these exercises are believed to produce the desired effect, they remain relatively unstudied. Subjects were instructed to avoid increased pain with all exercises and daily activities and were advised to position the upper extremity in a supported 40–50° scapular plane (25) elevation position (loose packed position) (34) when not using the extremity. This positioning not only helps to maximize the precarious vascularity of the cuff but also helps to minimize excessive tightening of the inferior capsule (3,62). Each subject's daily exercises and vocational and avocational activities were reviewed to ensure good quality exercise and avoidance of improper mechanics or overuse stress (16). Treatment was concluded with 10 minutes of soft tissue mobilization, including effleurage, friction, and kneading techniques, with the subject sitting with the arm supported in a relatively loose packed position. Each of these techniques was performed for approximately 1 minute each and repeated three times. The friction technique was specifically applied to the supraspinatus, bicipital long head, and subscapularis tendons. The last minute of treatment consisted of effleurage. Pressure, administered to subject tolerance, was applied to the soft tissues and humerus in a cephalic medial direction toward the body.

FIGURE 2. *Glenohumeral inferior glide without stabilization. ⇒ = direction of glide with force. (From Foley et al (14), reprinted with permission).*

Prior to the soft tissue treatment, the experimental group received a series of mobilization techniques to the subacromial and glenohumeral joints. The techniques were styled after Maitland (34) and described in detail by Foley et al (14). Capsular extensibility of all subjects was graded manually before and after treatment in four different directions (anterior, posterior, inferior, and long axis traction) using the Paris (44) 0–6 accessory movement scale. This grading scale, although not validated, was used to determine the direction(s) of restriction and guide the intensity of mobilization treatment. However, because of the poor reproducibility and accuracy of manual accessory movement testing (5,33,36,37,58), the grade of mobility was not used as a dependent variable in this study. Depending on the direction of restriction in capsular extensibility of each subject, four separate techniques were employed, including inferior glide (Figure 2), posterior glide (Figure 3), anterior glide (Figure 4), and long axis traction (Figure 5). The principal investigator applied oscillatory pressure of two to three oscillations per second (34). The grade [I–IV (34)] of stretch was largely dependent upon the patient's response and end-feel testing. For situations where pain or muscle spasm preceded a sensation of resistance, a grade I or II stretch was applied. As

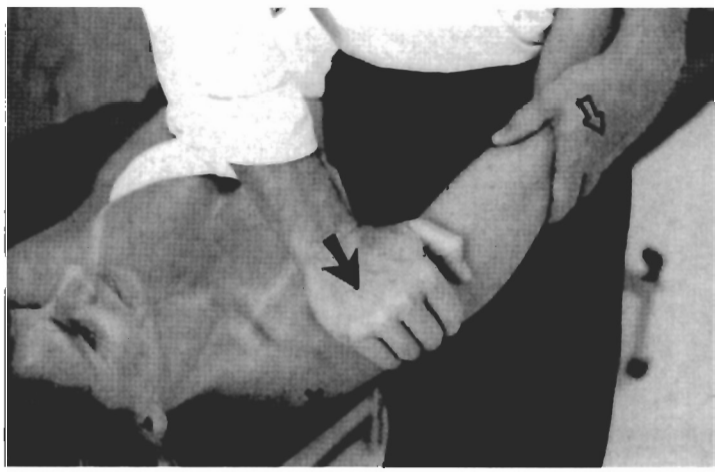

FIGURE 3. *Glenohumeral posterior glide. × = fixation or stabilization and ⇒ = direction of glide with force. (From Foley et al (14), reprinted with permission).*

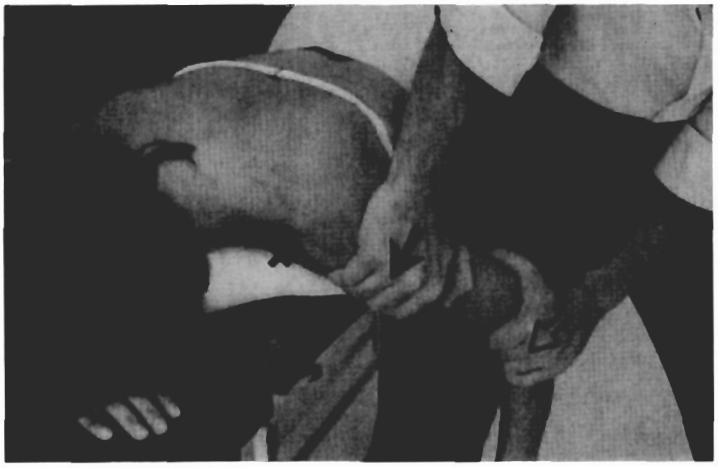

FIGURE 4. *Glenohumeral anterior glide. × = fixation or stabilization and ⇒ = direction of glide with force. (From Foley et al (14), reprinted with permission).*

the end-feel became more resistant and less painful, grade III and IV pressure was applied. Each indicated technique was administered two to four times (30 seconds each). As a result, the experimental group received a maximum of 15 minutes additional treatment compared with the control group. Posttreatment measurements were taken 1–3 days following the last treatment.

Data Analysis

Between-group comparisons on all descriptive and dependent variables were done at baseline using two-tailed, independent sample *t* tests for age, height, weight, range of motion, subacromial compression test pain, and 24-hour pain; Mann-Whitney *U* tests for the functional tests; and Fisher's Exact test for sex.

Because the sample was small, baseline differences between groups might not be statistically significant but could have affected the posttreatment analyses. Therefore, posttreatment comparisons of abduction, elevation, internal rotation, external rotation, 24-hour pain, and subacromial compression test pain were made with analyses of covariance using baseline values as covariates. Posttreatment flexion range was not normally distributed and was analyzed with the Mann-Whitney *U* test as were the functional tests. Baseline to posttreatment comparisons were done with one-tailed, paired *t* tests for range of motion (except flexion), 24-hour pain and subacromial compression test pain, and Wilcoxon matched pairs signed-ranks tests for flexion and the functional tests. Where there was a between-group difference on a variable, analyses were done within group; if there were no between-group differences, the groups were pooled for analysis.

To examine whether age, hand dominance, or duration of symptoms affected results, groups were created based on median age (<53 years or ≥53 years), side of involvement (dominant or nondominant), and median duration (<26 weeks or ≥26 weeks) and compared using two-tailed, independent sample *t* tests or Mann-Whitney *U* tests. All comparisons were made at the 0.05 level of significance.

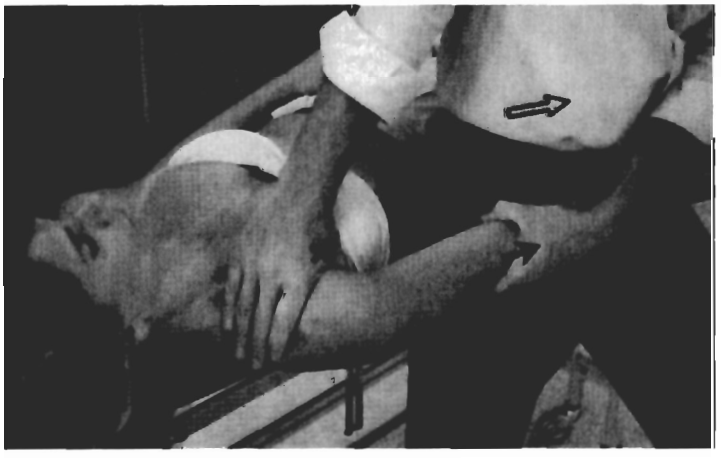

FIGURE 5. *Long axis traction. × = fixation or stabilization and ⇒ = direction of glide with force. (From Foley et al (14), reprinted with permission).*

RESULTS

At the beginning of the study, there were no differences between groups on the dependent variables of 24-hour pain, subacromial compression test pain, active range of motion, and functional skills (Tables 1 and 2). Both groups were similar in age, height, weight, and sex. All subjects were right-handed, and the majority (57%) experienced impingement syndrome on their nondominant side.

Following treatment, there were no differences in active range of motion measurements and the three functional shoulder movement skills between groups. The experimental group demonstrated less pain intensity over a 24-hour period and on the subacromial compression test at posttreatment compared with the control group (Tables 3 and 4). Tables 5 and 6 summarize the changes (pre to post) in score on each dependent variable for the experimental and the control group. The experimental group improved significantly on 24-hour pain and pain with subacromial compression testing, while the con-

Variable	Control Group	Experimental Group	U	p
Reaching to external occipital protuberance			11	NS
Can do	2	0		
Can do with pain	4	3		
Cannot do	1	4		
Reaching overhead 135°			11.5	NS
Can do	3	1		
Can do with pain	4	3		
Cannot do	0	3		
Reaching to spinous process			21	NS
Can do	0	0		
Can do with pain	3	2		
Cannot do	4	5		

NS = Not significant.

TABLE 2. *Frequencies and Mann-Whitney U tests at baseline for categorical dependent variables.*

trol group demonstrated no change on the pain variables. Both groups improved on motion and function. With groupings based on age, side of dominance, or duration of symptoms, there were no differences between groups on any of the dependent variables.

How well a subject attended treatment, exercised, or adhered to their home program might influence the results of this study. Subjects' exercise quality was rated by the principal investigator on a 4-point scale at each treatment. The categories of grading were poor (0 points), fair (1 point), good (2 points), and excellent (3 points). An average score of the nine sessions was computed and then converted to a percentage score. The percentage score was then used for analysis. Exercise adherence was tabulated based on the home exercise log. Subjects were instructed to exercise at home three times per day and to mark the daily log sheet each time they performed their home exercises. At the conclusion of their ninth treatment, a percentage was computed based on the number of times they actually exercised at home compared with the total number of times possible for 100% adherence. That percentage figure was then used for analysis. Mann-Whitney *U* tests demonstrated parity between groups in treatment attendance, exercise quality, and exercise adherence. Both groups demonstrated 96% treatment attendance, 63% in exercise quality, and 82% in exercise adherence.

Variable	Control Group ($N = 7$)		Experimental Group ($N = 7$)		F	p (one-tailed)
	$\bar{X}$	SD	$\bar{X}$	SD		
24-hour pain (mm)	44.09	31.98	12.02	14.35	8.304	.008
Subacromial compression test pain (mm)*	43.43	25.49	21.57	13.59	4.360	.032
Abduction (degrees)	133.86	27.82	125.71	26.21	.004	NS
Elevation (degrees)	148.57	15.47	141.29	19.54	.005	NS
External rotation (degrees)	81.14	18.05	75.71	17.51	.001	NS
Internal rotation (degrees)	49.57	16.42	44.86	12.25	.013	NS

** One subject dropped from the control group due to lack of understanding the instructions.*
NS = Not significant.

TABLE 3. *Means, standard deviations, and analyses of covariance for dependent variables following treatment.*

DISCUSSION

The purpose of this study was to evaluate the efficacy of joint mobilization on patients with primary shoulder impingement syndrome when administered in combination with a regimen of heat, soft tissue mobilization, strength and range of motion exercises, and patient education. Both the control and the experimental groups improved in range of motion and function; however, only the experimental group improved on 24-hour pain and pain with subacromial compression testing. The groups differed on pain reduction but not on motion and function.

Pain

Pain about the subacromial region has been reported to be a classic symptom of primary shoulder impingement syndrome (19,38). Yishay et al (68) discussed the role of pain in this condition, finding that after 14 patients received a subacromial injection to reduce pain, their active range of motion, pain, function, and strength improved. In our study, the experimental group not only had less pain than the control group, but the control group failed to show any appreciable reduction in pain at all. The difference in pain between groups might be explained through the neurophysiologic pain reduction phenomenon associated with graded movement. Neuromodulation of pain is reportedly achieved when stimulation of type I and II afferent articular mechanoreceptors reflexogenically reduces tone or the awareness of pain (67). In contrast, the experimental group did receive approximately 10–15 minutes more move-

Variable	Control Group	Experimental Group	*U*	*p* (one-tailed)
Reaching to external occipital protuberance			21.5	NS
Can do	5	4		
Can do with pain	1	2		
Cannot do	1	1		
Reaching overhead 135°			22.0	NS
Can do	5	5		
Can do with pain	2	1		
Cannot do	0	1		
Reaching to spinous process			23.5	NS
Can do	2	2		
Can do with pain	2	1		
Cannot do	3	4		
Flexion			17.0	NS

NS = Not significant.

TABLE 4. *Frequencies and Mann-Whitney U tests for categorical dependent variables following treatment.*

ment stimulation per treatment session than the control group which, when accumulated over 3 weeks, could potentially have accounted for the difference between groups.

The subacromial compression test is designed to determine if a painful response is elicited with passive indirect compression of the subacromial space. The subacromial compression test provoked significantly less pain in the experimental group compared with the control group, and again the control group experienced no improvement with this maneuver. It is conceivable that joint mobilization effectively stretched the posterior and inferior portions of the capsule to such a degree that, as the maneuver narrowed the humeral-acromial distance, the more extensible capsules of the experimental group allowed more opposite direction glide, resulting in less subacromial pressure and pain.

The subacromial compression test provoked significantly less pain in the experimental group compared with the control group.

Mobility

Impingement syndrome is commonly associated with limited active range of motion (38,61). Although pain reduced significantly in the experimental group, contrary to the results of Yishay et al (68), we did not see a commensurate increase in mobility. On pain-free active range of motion, the experimental group failed to show any statistical gains over the control group, but both groups demonstrated significant gains in all ranges. There are several potential explanations why there were no differences between groups on gains in motion. First, the improvement in range of motion may be in part the product of many factors, such as neurophysiologic reduction in pain and associated muscle guarding, mechanical reduction in edema, improved rotator cuff and shoulder girdle strength, or improved extensibility of the shoulder musculotendinous and capsuloligamentous structures. Goniometric measurements were chosen, not to account for the influence of each of these factors, but as a sensitive measure of change in motion. For the factor most relevant in this study, capsuloligamentous extensibility, perhaps the goniometric measurements of physiologic range were not the most specific measure to determine improvement and ulti-

Variable	Baseline		Posttreatment		*t*	*p* (one-tailed)
	$\bar{X}$	SD	$\bar{X}$	SD		
24-hour pain (mm)						
Control (*N* = 7)	48.07	21.33	45.86	33.26	.23	.823
Experimental (*N* = 7)	49.71	29.01	12.50	14.93	4.31	.005
Subacromial compression test pain (mm)*						
Control (*N* = 6)	56.71	31.42	53.57	32.86	.21	.842
Experimental (*N* = 7)	50.50	25.18	22.43	14.13	4.97	.003
Abduction (*N* = 14) (degrees)	102.93	29.41	129.79	26.31	−4.13	.0005
Elevation (*N* = 14) (degrees)	121.14	28.81	144.93	17.35	−3.59	.0015
External rotation (*N* = 14) (degrees)	64.29	22.50	78.43	17.32	−2.68	.0095
Internal rotation (*N* = 14) (degrees)	33.71	14.77	47.21	14.13	−4.51	.0005

* *One subject dropped from the control group due to lack of understanding the instructions.*

TABLE 5. *Means, standard deviations, and paired t tests for dependent variables at baseline and following treatment (N = 14).*

Variable	Better	Worse	Same	Z	p (one-tailed)
Reaching to external occipital protuberance	7	1	6	−2.17	.015
Reaching overhead 135°	7	0	7	−2.37	.009
Reaching to spinous process	6	1	7	−1.77	.038
Flexion	13	0	1	−3.18	.00075

TABLE 6. *Frequencies of subjects (N = 14) who improved, worsened, or stayed the same from baseline to posttreatment for categorical dependent variables and Wilcoxon tests.*

mately discern a difference between groups. Our current methods of ascertaining what factors limit motion, as well as measuring any change in those factors, are inadequate. Using accessory movement testing as a measurement variable would be logical, but, because of its low reliability and validity, it is of limited utility. Although goniometry cannot differentiate between groups on the basis of the specific state of capsuloligamentous extensibility, it is useful to determine the general arc of available motion to which capsular mobility theoretically contributes.

Secondly, joint mobilization may not be necessary to achieve improved range of motion when physiologic stretching (indirect) exercises are being performed, particularly if the degree of capsular tightness is mild. Direct capsular stretching through joint mobilization theoretically could improve joint arthrokinematic and active range of motion, particularly in the mid-ranges of humeral elevation, where improved opposite direction humeral head glide should act to reduce the propensity of impingement of the subacromial contents (27). Capsular stretching can also be accomplished through indirect means of physiologic stretching. The exercise regimen designed for both groups in this study included physiologic stretching exercises that not only stretched the musculotendinous structures but also indirectly stretched the various portions of the glenohumeral capsule. In this population of subjects, perhaps the degree of capsular tightness was such that physiologic stretching was adequate enough to improve range.

On the other hand, because mobilization was rendered with the joint in the mid-range, there may not have been adequate stretch to the capsule. Perhaps mobilization delivered at or near end range would have a more noticeable effect on mobility of the joint. The mid-range position appeared to be appropriate for the use of mobilization to alleviate pain but may not have been appropriate to improve mobility.

Third, low power as a result of the small sample can prevent differences from being detected. A power analysis using the means and arithmetic average of the standard deviations showed that for differences of the magnitude found in this study (5–11°) to be statistically significant at 80% power, sample sizes from 39 to 138 would have been necessary (46). Motion differences of this size may not be clinically meaningful, but, of more importance, the control group had the larger range of motion so statistical differences would have favored the control group.

A fourth explanation for the lack of differences in range of motion may be the result of improved rotator cuff strength and function. Both groups in this study were involved in exercises that strengthened the rotator cuff and large muscle groups of the shoulder complex. Perhaps the significant improvement in range of motion experienced by both groups is partly the result of improved strength and timing of the rotator cuff/deltoid muscle force coupling mechanism.

Function

Functional limitations, especially with combined movement patterns overhead, are commonly present with impingement syndrome. Both groups improved in function, but there were no differences in performance between groups. Functional limitations are assumed to be related to decreased mobility and pain associated with the condition. Improved mobility and pain would, therefore, be expected to lead to functional improvement. In this study, both groups improved similarly in mobility, but the mobilization group had greater improvement in pain measures. Greater improvement in function of the mobilization group would, therefore, be expected. However, this differential functional improvement did not occur, perhaps as a result of scale insensitivity.

Because no existing functional measurement scale of the shoulder specifically measures the movement patterns that consistently incite the signs and symptoms of primary shoulder impingement syndrome, a scale of three functional skills was devised for this study. The three-category system used for grading the functional skills combined the ability or inability to perform a skill with the presence or absence of pain. To achieve the most functional category would entail both restored mobility and elimination of pain. While the mobilization group had greatly improved pain, without the total obliteration of pain, they could not achieve the highest functional category, and the two groups appeared to be the same functionally. Perhaps a scale with more activities that reflected average daily use and more response categories would have detected improved function commensurate with the improved pain variables of the mobilization group.

Age of the patient and side of involvement were two additional variables that could have an influence on how patients with primary shoulder impingement syndrome heal. According to Neer's stages of involvement (38), age plays a critical role in the progression of this disease, with older patients generally having more advanced involvement and ultimately less potential to reverse their lesion. Research has shown that as people age, healing may be compromised due to a decrease in tendon vascularity and cellularity, disorganization and fragmentation of tendon collagen network, and decreased tensile strength to failure (6,54). Others have suggested that the perception of pain and response to exercise among older people may be altered (18,49). However, those subjects who are disadvantaged by advancing age may ultimately do better than their younger counterparts due to maturity or because they may be more risk averse.

Younger subjects, on the other hand, may heal more rapidly due to fewer age-related degenerative changes, but they may be disadvantaged secondary to increased activity risks (22), lack of treatment adherence, or both. In this study, age apparently had little influence on a subject's response to treatment for impingement syndrome. Considering there are advantages and disadvantages of age at either end of the spectrum, the effects may have ultimately balanced.

The effect of hand dominance was also explored relative to the rate of occurrence and the degree of improvement in this patient population. For this study, all subjects demonstrated right-hand dominance, but 57% sustained impingement on the nondominant arm. This finding is contrary to the conventional belief that a cumulative trauma condition, such as primary shoulder impingement syndrome, would be more prevalent in the dominant arm (61). The more frequent occurrence on the nondominant side in this study may simply be due to chance. Alternatively, perhaps a lack of conditioning may predispose the nondominant side to a greater rate of occurrence. Relative to degree of improvement, the nondominant upper extremity might be expected to heal more quickly because it is less likely to sustain the daily repetitive stress incumbent upon the dominant arm (61). When we subdivided our subjects based on side of involvement, we found that subjects with nondominant side involvement did no better on any variable than subjects with dominant side involvement. Based on the results of our study, primary shoulder impingement syndrome may occur more frequently on the nondominant side, but there is no difference between sides in degree of improvement.

Duration of involvement was also explored, theorizing that subjects with more chronic involvement may not respond as well as their shorter duration counterparts. We did not find any differences between subjects with <26 weeks of symptoms and subjects with ≥ 26 weeks of symptoms on any of the dependent variables.

In summary, the question asked in this study was one frequently encountered by clinicians; that is, whether joint mobilization is a necessary addition to a comprehensive treatment regimen. This study found that the comprehensive treatment program improved range of motion and function. When mobilization techniques performed in mid-range were added to that program, patients experienced improved pain.

Pain may have improved differentially as a result of neural mediations in response to mid-range oscillations. The improvements in shoulder range of motion may not have been group-specific because *1)* the strong effect of the comprehensive program was adequate in reducing subacromial crowding, improving humeral head depressor strength, and restoring capsular mobility; *2)* mobilization performed in mid-range was not adequate to stretch the capsule to a greater degree than physiologic end-range stretching; *3)* capsular tightness was mild in this population of primary shoulder impingement syndrome, making the addition of mobilization unnecessary; or *4)* goniometrics may not be specific enough to detect change in capsular mobility. Function improved for both groups but was not greater in the experimental group in spite of improved pain, probably because the functional scale did not have a sufficient number of categories for adequate responsiveness.

Further studies are required to explore treatment strategies for primary shoulder impingement syndrome using an adequate number of subjects to assure the power of their conclusions. Specific topics of study might include: *1)* the efficacy of the individual components of the comprehensive treatment regimen; *2)* the effectiveness of joint mobilization (direct) vs. physiologic (indirect) stretching exercises; *3)* the influence of mid-range vs. end-range joint mobilization on pain, range of motion, and function; *4)* reliable, responsive, and accurate measurements of capsular mobility and shoulder function; *5)* the occurrence and degree of improvement based on side of involvement and duration of the condition; *6)* the influence of rotator cuff strengthening on this population; and *7)* the role of dynamic (contractile) vs. static (inert) causation in primary shoulder impingement syndrome. These types of studies would serve to increase understanding of the multifactorial pathomechanics of impingement syndrome, refine measures of outcomes of treatment, and improve and define more accurately the indications for the use of joint mobilization.

CONCLUSION

This study provides preliminary evidence that the use of joint mobilization relieves pain over a 24-hour

period and with subacromial compression testing but may not be necessary to improve mobility and function in the treatment of primary shoulder impingement syndrome when combined with heat, active range of motion, physiologic stretching, muscle strengthening exercises, soft tissue mobilization, and patient education. JOSPT

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