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Comparison of Supervised Exercise With and Without Manual Physical Therapy for Patients With Shoulder Impingement Syndrome

Michael D. Bang, PT[1]
Gail D. Deyle, MPT, OCS[2]

Study Design: A prospective randomized clinical trial.
Objective: To compare the effectiveness of 2 physical therapy treatment approaches for impingement syndrome of the shoulder.
Background: Manual physical therapy combined with exercise is a commonly applied but currently unproven clinical treatment for impingement syndrome of the shoulder.
Methods and Measures: Thirty men and 22 women (age 43 years ± 9.1) diagnosed with shoulder impingement syndrome were randomly assigned to 1 of 2 treatment groups. The exercise group performed supervised flexibility and strengthening exercises. The manual therapy group performed the same program and received manual physical therapy treatment. Both groups received the selected intervention 6 times over a 3-week period. The testers, who were blinded to group assignment, measured strength, pain, and function before treatment and after 6 physical therapy visits. Strength was a composite score of isometric strength tests for internal rotation, external rotation, and abduction. Pain was a composite score of visual analog scale measures during resisted break tests, active abduction, and functional activities. Function was measured with a functional assessment questionnaire. The visual analog scale used to measure pain with functional activities and the functional assessment questionnaire were also measured 2 months after the initiation of treatment.
Results: Subjects in both groups experienced significant decreases in pain and increases in function, but there was significantly more improvement in the manual therapy group compared to the exercise group. For example, pain in the manual therapy group was reduced from a pretreatment mean (±SD) of 575.8 (±220.0) to a posttreatment mean of 174.4 (±183.1). In contrast, pain in the exercise group was reduced from a pretreatment mean of 557.1 (±237.2) to a posttreatment mean of 360.6 (±272.3). Strength in the manual therapy group improved significantly while strength in the exercise group did not.
Conclusion: Manual physical therapy applied by experienced physical therapists combined with supervised exercise in a brief clinical trial is better than exercise alone for increasing strength, decreasing pain, and improving function in patients with shoulder impingement syndrome. *J Orthop Sports Phys Ther 2000;30:126–137.*

Key Words: *exercise, manual physical therapy, shoulder impingement syndrome*

[1] *Coordinator, Primary Care Physical Therapy, Department of Medicine, Kaiser Permanente Medical Center, Vallejo, Calif.*
[2] *Colonel and chief of physical therapy, Brooke Army Medical Center, Fort Sam Houston, Tex.*
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Send correspondence to Michael D. Bang, Department of Medicine, Kaiser Permanente Medical Center, 975 Sereno Drive, Vallejo, CA 94590. E-mail: Mbang96@aol.com

Shoulder disorders are among the most common of all peripheral joint complaints.[6,37] The cumulative incidence of shoulder problems in general medical practice is estimated to be 11.2/1000 patients per year.[55] Shoulder impingement syndrome and rotator cuff tendinitis are considered to be the most frequent cause of intrinsic shoulder pain and disability.[26,38,55] Impingement in the shoulder occurs when the soft tissues occupying the subacromial space are encroached upon by the coracoacromial arch.[44] Outcome studies[7] reveal that these disorders are not necessarily self-limiting. Disorders involving shoulder impingement are often refractory to nonsurgical treatment including conventional physical therapy, and can result in chronic symptoms with functional impairment.[7,8] Shoulder impingement disorders are currently classified as either primary or secondary.[17,19,31]

Cumulative microtrauma sustained by the subacromial tissues during overuse and repetitive subacromial loading is the theorized cause of primary impinge-

ment.[23,31,43] Intrinsic degenerative tendinopathies of the rotator cuff and anatomic variations of the acromion process are thought to increase the vulnerability of this region to impingement.[41,47,54] Posterior capsule tightness and weakness of the shoulder rotator musculature have been reported in patients with primary shoulder impingement.[35,56]

Secondary impingement is reported in athletes who participate in sports that require frequent overhead activity.[17,19] The etiology of secondary impingement is considered to be subtle glenohumeral instability or hypermobility. It has been proposed that such instability combined with inadequate recruitment of the active stabilizers of the glenohumeral or scapulothoracic joint, results in excessive anterior and superior migration of the humeral head. Excessive displacement of the humeral head in turn encroaches on the soft tissues lying within the subacromial space.[19,20,22,31,51] Common clinical findings associated with secondary shoulder impingement are excessive range of motion (ROM) into external rotation, weakness of the internal rotators, and decreased endurance ratios of the shoulder abductors and external rotators.[4,56]

It has been determined that 15–28% of patients diagnosed with shoulder impingement syndrome may eventually require surgery.[3,41] Commonly prescribed treatments for shoulder impingement include nonsteroidal anti-inflammatory medications, thermal modalities, and subacromial corticosteroid injections.[23,31,57] Therapeutic exercise regimes are also advocated to restore shoulder mobility and stability, by improving ROM and enhancing glenohumeral as well as scapulothoracic muscle function.[32,33,41,48,58]

Brox et al[5] determined in a randomized controlled clinical trial that exercise supervised by a physical therapist was superior to placebo and was as effective as surgical subacromial decompression combined with postoperative rehabilitation in the treatment of patients with stage II primary impingement. A recent randomized, controlled study[18] reported improved ROM, decreased pain, and increased function in patients with shoulder pain. These patients received an individualized physical therapy program consisting of muscle stretching, strengthening, and retraining.

Physical therapists have advocated the use of passive joint mobilization, soft tissue mobilization, and muscle stretching as an effective means of treating shoulder dysfunction.[15,30,39] Passive joint mobilization is considered to be an effective treatment for enhancing ROM in the patient with shoulder impingement.[33,46] Nicholson[45] reported significant improvement with passive shoulder abduction in patients with adhesive capsulitis who received joint mobilization combined with active exercise.

The influence of thoracic spine mobility and curvature on shoulder ROM and scapular position;[10,11] the prevalence of significant forward head posture in subjects with shoulder overuse injuries[21]; and Schneider's reports[50] of increased lateral rotation of the shoulder following joint mobilization to the cervical spine in patients with suspected capsular contractures of the glenohumeral joint are examples of the interdependence among joints in the shoulder girdle. The complexity of joint function in the shoulder may require treatment of shoulder impingement to extend beyond the glenohumeral and subacromial joints.[29,30,46]

The purpose of our investigation was to compare the effectiveness of 2 physical therapy treatment approaches to shoulder impingement syndrome: (1) a shoulder exercise program supervised by a physical therapist, and (2) a shoulder exercise program supervised by a physical therapist combined with manual physical therapy to the upper quarter.

TABLE 1. Inclusion criteria.*

Category I: impingement signs†
1. Passive overpressure at full shoulder flexion with the scapula stabilized.
2. Passive internal rotation at 90° shoulder flexion in the scapular plane and in progressive degrees of horizontal adduction.
Category II: active shoulder abduction‡
Active shoulder abduction
Category III: resisted break tests§
1. Abduction.
2. Internal rotation.
3. External rotation.

*To be included in the study participants were required to have: (1) pain with 1 of the 2 tests in category I, and (2) pain with 1 test from either category II or category III.
† Subject standing.
‡ Subject standing against a wall.
§ Subject supine with the shoulder in 30° abduction, the elbow in 90° flexion, and the forearm neutral.

METHODS

Subjects

Fifty-two subjects, 30 men and 22 women, meeting the inclusion criteria (Table 1) were randomized into 1 of 2 treatment groups: the exercise group or the manual therapy group (Table 2). All subjects were referred by physicians with the diagnoses of shoulder impingement syndrome, rotator cuff tendinitis, or shoulder tendinitis. Subjects were subsequently carefully screened for the diagnosis of impingement syndrome according to the established inclusion criteria. Each subject participated under informed consent of their rights and under guarantee of full disclosure of the benefits and risks of the study. The study received institutional review board approval at each of the 4 participating sites (Kaiser Permanente Fairfield, Pleasanton, and Fremont in northern California, and Brooke Army Medical Center at Fort Sam Houston, Tex).

TABLE 2. Descriptive statistics for subjects.

	Manual therapy group	Exercise group
Sex		
Men (*n*)	18	12
Women (*n*)	10	12
Age (years)		
Mean ± SD	42 ± 10.1	45 ± 8.4
Range	27–65	24–60
Duration of symptoms (months)		
Mean ± SD	5.6 ± 3.7	4.4 ± 2.8
Range	1–12	1–12
Dominant arm involved (%)	63	66

SD indicates standard deviation.

TABLE 3. Exclusion criteria.

1. Changes in medications less than 2 weeks before or during the study.
2. Any other form of treatment for shoulder pain during the study.
3. Pending litigation or workman's compensation claim.
4. History and physical suggestive of a rotator cuff tear or adhesive capsulitis.[14]
5. History of shoulder dislocation, subluxation, or fracture.
6. Cervical radiculitis or radiculopathy.
7. History of cervical, shoulder, or upper back surgery.
8. History of systemic or neurological disease.
9. Physical therapy or chiropractic treatment for the shoulder, neck, or upper back in the last 12 months.
10. Insufficient English language skills to comprehend all explanations and respond to questions.

All participants were required to be between 18 and 65 years of age and to have pain with 1 of the 2 tests in category I (which, in combination, have been shown to be highly sensitive for identifying impingement lesions under the coracoacromial arch[24,36,43]) and pain with 1 test from either category II[34] or category III[12] (Table 1). To participate in the study, subjects had to be willing to remain on current levels of medication (initiated at least 2 weeks prior to the study), for the duration of the study. Patients were excluded from the study if they received any other form of medical treatment during the course of the study that could influence the dependent variables. Additional exclusion criteria are described in Table 3.

Dependent Variables

We measured the patient's perception of shoulder function, pain response, and isometric strength using a functional assessment questionnaire, a visual analog scale, and a stabilized electronic dynamometer.

The functional assessment questionnaire was developed in 1993 as a measurement tool for our pilot study and was modeled after the Owestry Low Back Disability Questionnaire.[16] It consists of 9 distinct categories. The first category reflects the current level of pain with general daily activity. The 6 levels of possible responses for this category range from no pain to pain in the shoulder at all times. The remaining 8 categories assess limitations in specific activities. Each of these categories also contain 6 descriptive statements that descend in order from no limitation at all to inability to perform the activity (Table 4). Each section was scored on a scale of 0 to 5. The scores of all sections were summed with a maximum possible score of 45 points representing no limitations in the areas assessed. In a separate reliability study, 24 subjects with shoulder impairment were tested and then retested 24 hours later. The test-retest reliability coefficient for the functional assessment questionnaire was shown to be 0.81 intraclass correlation coefficient (ICC) of (3,1). The ICC was computed using mean square values derived from a mixed model, 2-way (trial × subjects) analysis of variance (ANOVA).

Subjective pain responses were recorded for the functional assessment activities, during resisted break tests, and during active abduction of the shoulder using the visual analog scale, which has been shown to be a reliable tool for measuring pain.[28] A 10-cm line was used for each test. The extreme limits were marked with perpendicular lines using the verbal descriptors of "no pain" and "worst pain I can imagine." The subjects were not shown their previous markings when follow-up measurements were taken. Measurements were expressed in millimeters.

The visual analog scale was applied to each of the 9 categories of the functional assessment questionnaire (Table 4). This measurement tool was referred to as the functional visual analog scale. Subjects were asked to draw a perpendicular mark on the line to

TABLE 4. Functional assessment questionnaire categories and examples of descriptive statements for the functional category of raising arm overhead.

Category	Score	Descriptive statement examples for raising arm overhead*
1. Overall pain intensity	[5]	I have no pain raising my arm overhead.
2. Raising arm overhead	[4]	I can raise my arm overhead, but I have mild pain.
3. Behind the back activities	[3]	I can raise my arm overhead, but I move slowly and carefully due to pain.
4. Reaching across body	[2]	Pain prevents me from raising my arm overhead with some activities.
5. Lifting with problem arm	[1]	Pain prevents me from raising my arm overhead with most activities.
6. Lying on shoulder	[0]	I cannot raise my arm overhead at all.
7. Pushing and pulling		
8. Carrying an object with arm at side		
9. Performance of usual physical activity, sport, or hobby		

*Reaching a shelf in a closet or cupboard, putting on a T-shirt.

indicate the level of pain they were currently experiencing in that functional category. The visual analog scale was also used to rate the amount of pain experienced during resisted break tests for shoulder internal rotation, external rotation, and abduction. Here the examiner applied manual force to slightly overcome the subject's resistance in order to break the muscle contraction. Each resisted break test consisted of 1 trial test repetition (about 50% effort), followed by 1 maximal effort repetition. A 10-second rest separated the 2 repetitions. Finally, the visual analog scale was used to measure the amount of pain experienced during active abduction. The sequence consisted of 1 trial repetition followed by 1 test repetition.

Isometric strength for internal rotation, external rotation, and abduction was assessed using an Accuforce II electronic dynamometer (AMETEK, Largo, Fla). Measurements were recorded in pounds (lb) and converted to Newtons. To ensure maximal stabilization, the device was mounted on a metal platform that was securely bolted to the frame of the examination table. The subjects were positioned supine with their involved shoulder in neutral flexion, extension, and rotation with the elbow in 90° of flexion, and neutral forearm pronation and supination. A 20° rubber wedge was placed with the apex in the axilla to ensure consistent positioning of shoulder abduction. The subject's involved arm, chest, and pelvis were stabilized on the table with belts (Figure 1).

Standardized markings from easily identifiable bony landmarks in the forearm were used for consistent positioning of the dynamometer. Four 5-second isometric contractions were performed for each of the 3 muscle groups tested; the first contraction was a practice repetition. Each subject was verbally commanded to gradually build force to its peak within the first 3 seconds and then continue to hold until instructed to relax. Thirty-second rest periods were given between contraction measurements of the same muscle group. Two-minute rest periods were given between contraction measurements of different muscle groups. Interrater reliability for isometric strength testing using this procedure was established on 10 subjects with nonimpaired shoulders prior to the initiation of the study. Intraclass correlation coefficients (2,3) were determined: internal rotation, 0.97; external rotation, 0.94; and abduction, 0.89. The ICC was calculated based on a 1-way repeated-measures ANOVA using Rater (5 levels: rater 1–5) as the independent variable.

Procedure

Each of the 4 research sites had 1 research team consisting of a tester and a treater. The testers were responsible for measurement of all dependent variables and were blinded to the group assignment for each subject. The treaters were experienced physical therapists who had also completed a 1-year full-time residency in advanced orthopedic manual therapy. They were responsible for screening, examining, and treating the subjects.

All screening, testing, and examination procedures were standardized and preprinted on data recording forms. Each research team was instructed in all procedures prior to initiation of the study. The methods used to ensure competency and uniformity included written instruction, video presentation, and group practice. The study was conducted over 6 physical therapy sessions in a 3–4-week period. A seventh visit was required for retesting of the isometric strength and perceived pain-dependent variables. The functional assessment questionnaire and the functional visual analog scale were completed at the beginning of treatment and again 60 days later as a means of assessing pain and functional status approximately 1 month after the conclusion of treatment.

Upon receiving the physical therapy referral, the treaters screened each candidate according to the inclusion and exclusion criteria (Tables 1 and 3). Patients who qualified and accepted the opportunity to participate in the study were scheduled for the initial evaluation and testing; 2 patients declined to participate. On day 1, subjects signed the informed consent and were appointed to either the exercise group or the manual therapy group using the table of random numbers. Subjects were then directed to the tester who performed the initial measurements of all the dependent variables. Afterwards, the subjects returned to the treaters for a subjective and objective examination of the upper quarter. The subjective examination included identifying the location, stability, and behavior of the subject's symptoms. A detailed history was obtained, and special questions such as the presence or change of a chronic cough, a recent fever, multiple joint pains, or morning stiffness were asked of each patient directed at screening for systemic disease and other nonmusculoskeletal problems. The physical exam consisted of active, passive, and accessory motion testing of the shoulder, shoulder girdle, and cervical and thoracic spine from C2 to T6. Additional upper-quarter examination procedures included a segmental neurological screening, manual muscle testing, and palpation. Following the examination process, treatment was initiated for both groups (Table 5).

Two months after the initiation of treatment, subjects in both groups completed the functional assessment questionnaire and functional visual analog scale for the final time, and mailed them along with the home exercise program log sheet to the research team.

Treatment

Treatment for both groups consisted of a standardized flexibility and strengthening program that was

FIGURE 1. Isometric strength testing.

performed in the clinic under the direct one-to-one supervision of a physical therapist. The manual therapy group additionally received manual physical therapy treatment directed at relevant movement limitations found in the upper quarter. Both groups were treated in the physical therapy clinic twice weekly for 3 weeks for a total of 6 visits. Both groups received 1-hour initial examinations with an additional half hour for testing of the dependent variables. All treatment sessions for both groups were one-half hour in length.

The flexibility program consisted of 2 passive stretching exercises, one for the anterior shoulder musculature and the other for the posterior shoulder capsule and surrounding musculature (Figure 2). Each stretch was held for 30 seconds and performed 3 times with a 10-second rest period between each stretch. They were performed once daily at home. On days that they were treated in the clinic, the exercise group subjects performed their stretches in the clinic as part of the supervised exercise program. The manual therapy group performed their stretches at home. This procedure was used to equalize the length of the treatment sessions between the 2 groups.

There were 6 strengthening exercises, all of which have been recommended as the essential "core exercises" of any shoulder rehabilitation program (Figure 3).[42,53] Four of the strengthening exercises required the use of Theratubing (Hygenic Corporation, Ak-

TABLE 5. Clinical treatment procedures.

Clinical session	Procedure
Treatment visit 1	Instructed in stretching program. Manual therapy group received manual therapy treatment and performed stretches at home. Exercise group performed stretches in clinic.
Treatment days 2–6	Both groups received re-evaluation and assessment of response to treatment. Manual therapy group received manual therapy treatment and performed strengthening in clinic and stretching at home. Exercise group performed stretches and strengthening exercises.
Clinic day 7	Both groups underwent posttreatment measurement of pain and strength. Both groups received instruction and compliance log for home program of daily stretching and 3-times weekly strengthening.

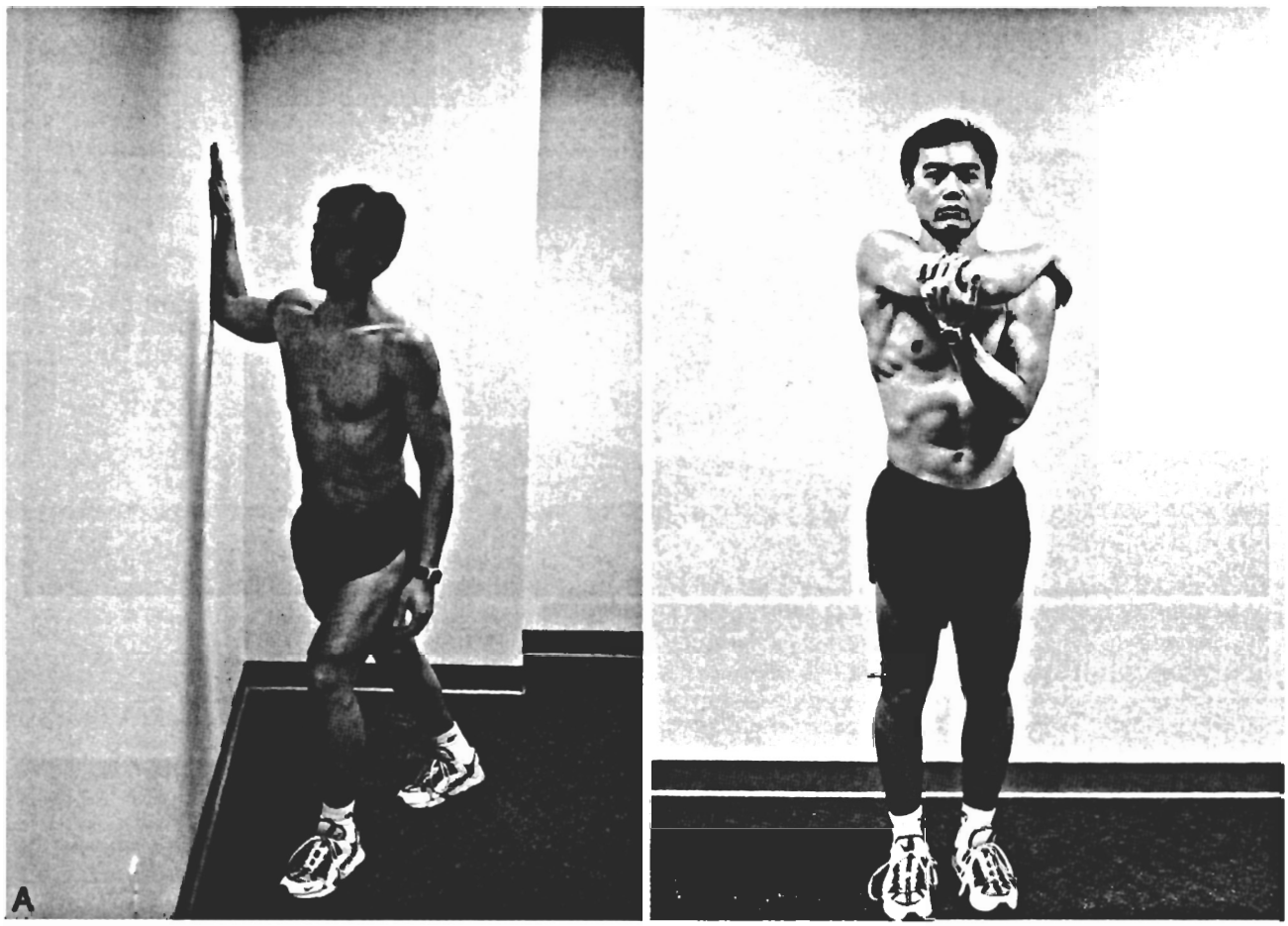

FIGURE 2. Flexibility stretches: (A) stretch for anterior shoulder musculature, and (B) stretch for posterior shoulder musculature.

ron, Ohio) in 6 levels of resistance. These exercises included shoulder flexion, scaption, rowing, and horizontal extension-external rotation. For each of the tubing exercises, a 10-repetition maximum was determined. This determination was based on the examiner's observation of movement quality and the subject's responses with regard to fatigue and pain. Deterioration in movement quality or pain exceeding a mild discomfort was avoided during all strengthening exercises by either reducing the level of resistance or modifying the ROM until the subject was able to progress. The level of tubing resistance was adjusted accordingly for all subjects throughout the treatment process. Each tubing exercise was performed as 3 sets of 10 repetitions with a 60-second rest period between each set.

The remaining 2 exercises, the seated press-up and the elbow push-up plus (a modification of the push-up plus) did not require any equipment beyond a stable chair or bench and a firm surface to lie on.[32] Both were performed to fatigue or for a maximum of 25 repetitions. The quality of all repetitions of each exercise was continuously monitored by the treating physical therapist.

In addition to the standardized exercise program, the manual therapy group also received manual therapy techniques specifically applied to movement limitations in the upper quarter that had been identified as relevant to the patient's problem during the initial examination. The manual therapy treatment was primarily aimed at the shoulder, but may also have been directed to the shoulder girdle, the cervical spine, and the upper thoracic spine including the costotransverse articulations. In most cases, passive accessory or passive physiological joint mobilization Maitland grades I–V were used.[40]

Initial treatment application was generally aimed at any identified movement limitations at the glenohumeral joint. A typical initial treatment may have involved manual therapy techniques to: (1) enhance glenohumeral caudal glide in positions of flexion or abduction, and (2) increase physiological flexion or internal rotation. Modification or progression of treatment on subsequent visits was contingent on findings in the reassessment process. For example, a plateau in progress with treatment focused to the glenohumeral joint would prompt the treater to: (1) change the vigor of the technique used, (2) change technique, or (3) direct treatment toward relevant movement limitations in the articulations of the shoulder girdle or axial skeleton. Typical treatment during subsequent visits may have involved manual

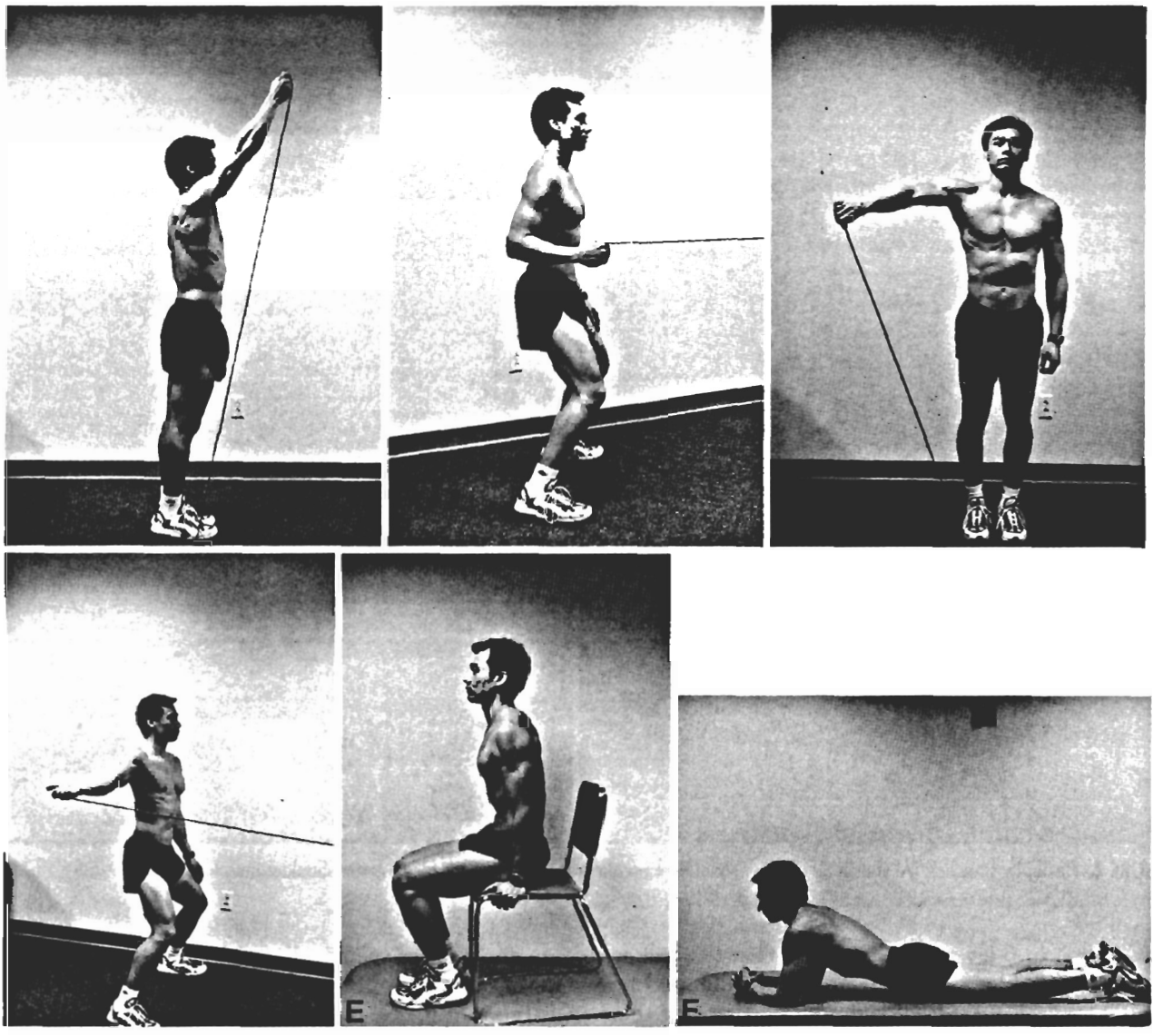

FIGURE 3. Strengthening exercises for the rotator cuff and scapula musculature: (A) shoulder elevation, (B) rowing, (C) scaption, (D) horizontal extension-external rotation, (E) seated press-up, and (F) elbow push-up plus.

therapy techniques to: (1) improve the combined physiological movements of hand behind back or shoulder quadrant, (2) increase upper thoracic extension and side bend, or (3) enhance extension, rotation, or side bend of the cervical spine. Techniques also included soft tissue massage and muscle stretching particularly of the pectoralis minor, infraspinatus, teres minor, upper trapezius, sternocleidomastoid, and scalenes musculature. These manually applied treatment techniques have been described in detail.[15,40] All manual therapy treatments were based on the findings of the upper quarter differential examination. Patients in the manual therapy group also typically performed 1 or 2 additional home exercises specifically aimed at reinforcing the effect of the manual therapy procedures. Examples of these include simple cervical and thoracic postural exercises such as chin tucks, and self-mobilization such as caudal glides of the glenohumeral joint. The prescription of specific "treatment-reinforcing" home exercise reflects common clinical practice for physical therapists that treat with manual therapy.

Data Analysis

For entry into the analysis, composite scores were created from scores on individual strength tests, from the visual analog scale scores and from the functional assessment questionnaire. These composite scores were the simple arithmetic sums of all component scores in each category. The sample size did not justify multivariate analysis of all the dependent variables. Global improvement was inferred from the composite scores. Data sets were complete for all subjects except one, for whom there were no functional visual analog scale scores.

Data were analyzed descriptively and with a 2 × 2 mixed model MANOVA and subsequent post hoc 2

TABLE 6. Results of a 2 × 2 mixed-model MANOVA and univariate ANOVA source table for function, pain, and strength.

Source of variance	*df*	*F*	*P* value
MANOVA			
Group	3,45	3.02	.0393*
Time	3,45	35.79	<.0001*
Time × group	3,45	5.08	.0042*
Function			
Between subjects			
Group	1	3.01	.0893
Within subjects			
Time	1	70.36	<.0001†
Time × group	1	8.72	.0049†
Pain			
Between subjects			
Group	1	2.11	.1534
Within subjects			
Time	1	94.93	<.0001†
Time × group	1	11.15	.0017†
Strength			
Between subjects			
Group	1	6.53	.0138†
Within subjects			
Time	1	18.75	.0001†
Time × group	1	6.29	.0155†

* α = .05.
† Bonferroni-corrected α = .017.

× 2 univariate ANOVAs using SPSS version 6.1.2 (SPSS, Chicago, Ill) for Windows software (Microsoft Corp, Redmond, Wash), with α set to .05. Bonferroni corrections were made to the significance level for post hoc univariate analyses to control for type I error. Subsequent post hoc pairwise comparisons to analyze interaction effects were performed with the Tukey procedure, also using an α level of .05.[49] Independent variables were Time (within subjects) with 2 levels (pretreatment and posttreatment) and Group (between subjects) with 2 levels (manual therapy and exercise). The 3 dependent variables were pain, strength, and function.

Statistical diagnostic procedures were performed on the data using the same SPSS statistical software to test for violations in the assumptions of the normality and homogeneity of variance.

RESULTS

Two subjects did not complete the study. One subject from the manual therapy group was excluded from the study after the second visit due to injuries sustained in a motor vehicle accident. The other subject, from the exercise group, elected to drop from the study after day 1 citing job-related issues. All home exercise program compliance logs were returned and indicated that patients from both groups were fully compliant.

Statistical diagnostic tests revealed no violations of the assumptions of normality and homogeneity of variance for any of the dependent variables. The overall MANOVA yielded a significant time × group interaction effect and significant main effects for both Time and Group (Table 6). Post hoc univariate ANOVAs for each of the 3 dependent variables revealed significant disordinal time × group interactions for function and pain and a significant ordinal interaction for strength (Table 6). These interaction effects are graphically presented in Figures 4, 5, and 6. Descriptive statistics are presented in Tables 7 and 8.

Subsequent post hoc pairwise comparisons performed for each of the significant interaction effects revealed the following. Subjects in both groups improved in their functional assessment questionnaire scores, but there was significantly more improvement in the manual therapy group (35% vs 17% for the exercise group). Subjects in both groups significantly reduced their visual analog scale scores after treatment, but there was significantly less pain in the manual therapy group (70% vs 35% for the exercise

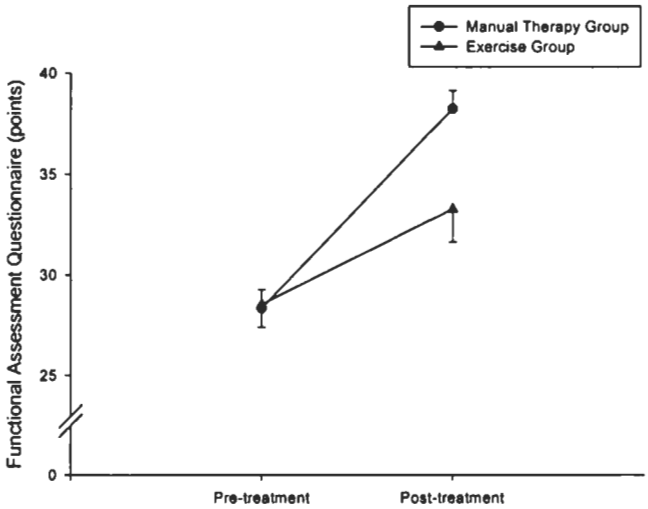

FIGURE 4. Functional assessment questionnaire scores in the manual therapy and exercise groups before and after treatment. Means ± standard errors of the mean are represented.

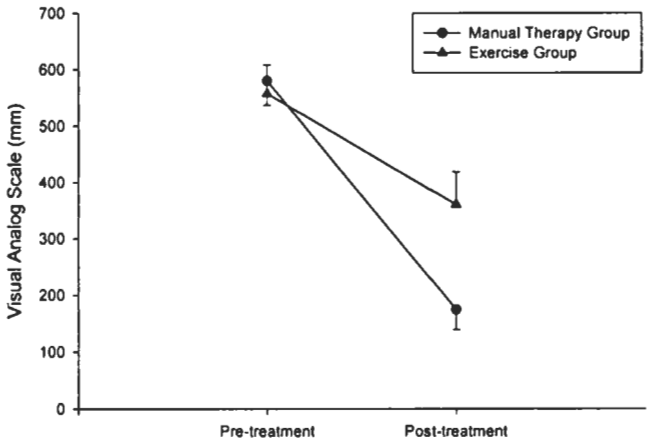

FIGURE 5. Summed scores of the visual analog scales in the manual therapy and exercise groups before and after treatment. Means ± standard errors of the mean are represented.

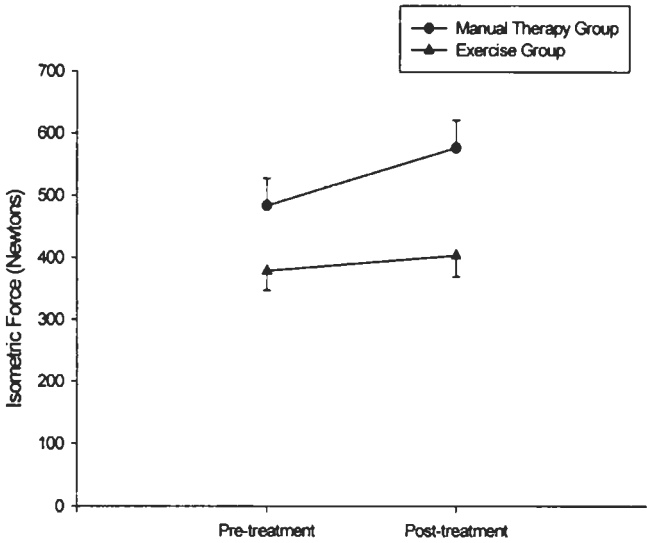

FIGURE 6. Summed scores of force measures in the manual therapy and exercise groups before and after treatment. Means ± standard errors of the mean are represented.

group). Subjects had equivalent functional assessment questionnaire and visual analog scale scores in both groups before treatment, but posttreatment scores were significantly different between the 2 groups for these 2 scales (Figures 4 and 5). Although subjects in the manual therapy group had significantly higher strength scores pretreatment, these subjects significantly increased their posttreatment strength scores by 16% while subjects in the exercise group did not significantly improve their strength scores (Figure 6).

DISCUSSION

In this study, supervised shoulder exercise combined with manual physical therapy proved to be superior to supervised shoulder exercise alone for decreasing pain, increasing strength, and improving function in subjects with shoulder impingement syndrome. Statistically significant decreases in pain and increases in strength were measured in the manual therapy group after completing only 6 physical therapy visits over a period that varied from 21–27 days. The statistically significant improvements in function were measured 2 months after initiating treatment.

The changes produced in the patients receiving manual therapy plus exercise are both statistically and clinically relevant. Patients reported improvement in the spectrum of functional activities ranging from simple forward and overhead reaching to more complex military and athletic activities such as performing pushups, throwing a baseball, and executing a hockey slap shot.

Therapeutic exercise has previously been determined to have long-term benefits for patients with shoulder impingement syndrome.[5,41] Based on the significant improvement in strength in the manual therapy group, the application of manual physical therapy appeared to optimize conditions for performing the strengthening exercises. These optimum conditions may be due to the significant pain reduction in the manual therapy group. Subjects in the manual therapy group were frequently observed to have increased pain-free ROM immediately following the application of manual therapy procedures.

Manual physical therapy might reduce pain by stimulating joint mechanoreceptor activity, which, in turn, is thought to block aberrant afferent pain signals and reduce the awareness of pain.[59] It has also been hypothesized that manual therapy mechanically stretches shortened collagenous tissue and improves interstitial fluid content resulting in restoration of movement.[52]

Poor recruitment and altered timing of the shoulder and shoulder girdle musculature have been shown to exist in some shoulder pain syndromes.[20,51] The significant improvement in strength demonstrat-

TABLE 7. Descriptive statistics for individual measures and composite dependent variables for the manual therapy group before and after treatment.*

	Pretreatment			Posttreatment		
	N	Mean	SD	*N*	Mean	SD
Abduction strength	27	192.39	110.40	27	225.30	111.86
External rotation strength	27	122.01	46.29	27	159.05	77.83
Internal rotation strength	27	168.90	86.86	27	191.96	82.29
Strength composite score†	27	483.30	227.83	27	576.31	228.75
Abduction AROM pain	27	48.26	23.43	27	16.82	21.02
Resisted abduction pain	27	42.59	26.35	27	22.70	26.27
Resisted external rotation pain	27	43.67	31.48	27	15.85	21.92
Resisted internal rotation pain	27	41.48	26.77	27	21.04	27.97
Functional pain	27	399.85	168.88	27	98.00	107.37
Pain composite score†	27	575.85	220.00	27	174.41	183.06
Functional assessment questionnaire†	27	28.33	4.75	27	38.22	4.68

* Strength scores are expressed in Newtons; pain scores are expressed in millimeters (from visual analog scales); and functional assessment questionnaire scores are expressed in points. The strength and pain composite scores were calculated by summing the individual measures listed above each composite score. SD indicates standard deviation; AROM, active range of motion.
† Composite dependent variables.

TABLE 8. Descriptive statistics for individual measures and composite dependent variables for the exercise group before and after treatment.*

	Pretreatment			Posttreatment		
	N	Mean	SD	*N*	Mean	SD
Abduction strength	23	130.79	74.51	23	147.14	81.11
External rotation strength	23	99.83	40.77	23	101.88	42.06
Internal rotation strength	23	147.26	61.27	23	153.62	58.63
Strength composite score†	23	377.88	148.28	23	402.64	162.50
Abduction AROM pain	23	50.41	22.92	23	37.54	29.01
Resisted abduction pain	23	35.27	27.77	23	32.64	29.45
Resisted external rotation pain	23	37.98	30.03	23	30.23	29.72
Resisted internal rotation pain	23	46.27	27.99	23	33.5	27.57
Functional pain	22	387.18	156.58	22	226.73	194.73
Pain composite score†	22	557.11	237.20	22	360.64	272.32
Functional assessment questionnaire†	23	28.52	5.47	23	33.26	7.84

* Strength scores are expressed in Newtons; pain scores are expressed in millimeters (from visual analog scales); and functional assessment questionnaire scores are expressed in points. The strength and pain composite scores were calculated by summing the individual measures listed above each composite score. SD indicates standard deviation; AROM, active range of motion.
† Composite dependent variables.

ed by the manual therapy group was clearly related to the application of manual physical therapy in the clinic and the manual therapy home exercises combined with exercise given to both groups. The exercise group did not improve significantly despite performing the identical flexibility and strengthening program. Although the manual therapy group was stronger overall than the exercise group at the initiation of the study, there was no significant difference in initial pain or function between the groups. DeVries[13] has proposed that beginning strength has no physiologic meaning, but training status will determine the potential for strength gains. He suggests that untrained individuals gain strength at much greater rates than individuals with an established training program.[13] Therefore, because the exercise group had the lowest entry strength scores, they should have made the greatest strength gains.

Common patterns of movement limitations were observed in most of the subjects. These patterns included: limited shoulder flexion, abduction and internal rotation; limited accessory glenohumeral movements directed caudally, and anterior to posterior with a caudal emphasis; and limited movements of hand behind the back and reaching across the chest. Limitations in ipsilateral physiologic (limb motion) and accessory (joint surface) motion were noted in the lower cervical region and upper thoracic spine in most subjects. Both impingement signs as described in the inclusion criteria were found to be positive in 90% of our subjects (47/52). Pain during active shoulder abduction was present in 96% of our subjects (51/52).

The treatment procedures used in this study could easily be incorporated into the graduated treatment model described by Holmes et al[27] as a realistic model for delivery of services in the managed care arena. The model emphasizes a minimal number of office visits and focuses on patient education, home exercise programs, and specific manual physical therapy intervention.

Ideally, this study would have used a shoulder scoring system with established reliability and sensitivity to evaluate subjects. However, after carefully reviewing the literature we found that the currently used assessment tools were designed and best suited to measure changes in function associated with shoulder arthroplasty. At the time we initiated our study, the reliability of these tools was unknown.[1,2,9,25,44]

Although our comparison study did not include a control group, Brox et al[5] has shown that exercise supervised by a physical therapist is superior to placebo and is equally as effective as surgical intervention combined with postoperative rehabilitation in patients with primary shoulder impingement. It is important, particularly from a cost-benefit perspective, that a small number of physical therapy visits may produce statistically and clinically significant changes in strength, pain, and function that are possibly equivalent or superior to surgery.

There is the possibility the "hands-on" treatment of manual therapy is perceived by the patient as more intensive care compared to no manual treatment. We tried to minimize this potentially confounding variable by performing the same hands-on re-evaluation of relevant objective findings at the beginning and end of each treatment session for both groups. Both groups also received direct supervision of the strengthening program and the exercise group performed the stretching exercises also under direct supervision of the treating therapist. The length of the treatment sessions was kept equal between groups. The exercise group performed the stretching exercises in the clinic while the manual therapy group performed them at home to allow time for the manual therapy treatment. In the end, however, it is undeniable that the manual therapy

group received more "hands-on" time than the exercise group received.

CONCLUSION

Manual physical therapy combined with supervised shoulder exercise is superior to supervised shoulder exercise alone for enhancing strength and function and reducing pain in patients with shoulder impingement syndrome. Our study also provides evidence that effective outcomes are attainable after relatively few physical therapy visits. It is important to recognize the functional interdependence of the joints and soft tissues in the upper quarter when treating dysfunction of the shoulder.

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