J Shoulder Elbow Surg (2009) 18, 138-160

ELSEVIER

Journal of Shoulder and Elbow Surgery

www.elsevier.com/locate/ymse

REVIEW ARTICLES

Exercise in the treatment of rotator cuff impingement: A systematic review and a synthesized evidence-based rehabilitation protocol

John E. Kuhn, MD*

Vanderbilt Shoulder Center, Nashville, TN

Summary A systematic review of the literature was performed to evaluate the role of exercise in treating rotator cuff impingement and to synthesize a standard evidence-based rehabilitation protocol. Eleven randomized, controlled trials (level 1 and 2) evaluating the effect of exercise in the treatment of impingement were identified. Data regarding demographics, methodology, and outcomes of pain, range of motion, strength, and function were recorded. Individual components of each rehabilitation program were catalogued. Effectiveness was determined by statistical and clinical significance. Although many articles had methodologic concerns, the data demonstrate that exercise has statistically and clinically significant effects on pain reduction and improving function, but not on range of motion or strength. Manual therapy augments the effects of exercise, yet supervised exercise was not different than home exercise programs. Information regarding specific components of the exercise programs was synthesized into a gold standard rehabilitation protocol for future studies on the nonoperative treatment of rotator cuff impingement.

Systematic reviews of interventions for rotator cuff pathology and shoulder pain suggest that exercise may be an effective treatment,[1,12,15,16] whereas ultrasound therapy is of little benefit.[16,28,37] Exercise is a broad term and includes the following interventions: range of motion, stretching and flexibility, and strengthening exercises, with manual therapy and modalities. Variations on individual exercises and these components have been promoted by a number of authors who offer rehabilitation protocol suggestions.[4,6,7,10,13,20,21,22,23,26,29,30,31] These protocols are typically extrapolated from animal studies, cadaver biomechanics studies, and studies of healthy subjects by using magnetic resonance imaging, video kinematics, electromyography, and strength measurements. As such, the protocols recommended by these authors are not based on high levels of evidence.

Not surprisingly, there is no consensus on an ideal exercise program to treat patients with rotator cuff disease, leading researchers who wish to conduct randomized trials to resort to using expert opinion (level 5 evidence) when developing protocols.[3] The purpose of this systematic review is evaluate the role of exercise in treating rotator cuff impingement and to develop an evidence-based gold standard, physical therapy, exercise program for the treatment of rotator cuff impingement syndrome by synthesizing the features of exercise protocols from clinical studies with the highest levels of evidence.

This work was funded by an unrestricted research grant from the Arthrex Corporation.

*Reprint requests: John E. Kuhn, MD, Associate Professor and Chief of Shoulder Surgery, Vanderbilt Sports Medicine, 4200 MCE, South Tower, 1215 21st Ave S, Nashville, TN 37232.

E-mail address: j.kuhn@vanderbilt.edu

1058-2746/2009/$36.00 - see front matter © 2009 Journal of Shoulder and Elbow Surgery Board of Trustees.
doi:10.1016/j.jse.2008.06.004

Materials and methods

Before the search was initiated, inclusion and exclusion criteria for articles were defined. Articles were included if they were level 1 or level 2 studies (randomized controlled trials), compared physical therapy with other treatments or placebo, used outcome measures of pain, function, or disability with validated assessment tools, and were restricted to patients with a diagnosis of impingement syndrome, as determined by positive a impingement sign by Neer[32] or Hawkins[18] criteria, or both. Articles were excluded if they were concerned with other shoulder conditions (calcific tendinosis, full thickness rotator cuff tears, adhesive capsulitis, osteoarthritis, etc), addressed postoperative management, were retrospective studies or case series, or used other outcome measures.

A computer search was conducted using the following databases: PubMed, Ovid, the Cochrane Central Register of Controlled Trials, Cochrane Database of Systematic Reviews, American College of Physicians (ACP) Journal Club, and Database of Abstracts of Reviews of Effects. Search words included *shoulder*, *impingement*, *rotator cuff*, *rehabilitation*, *physical therapy*, *physiotherapy*, or *exercise*. The combined search produced 12,428 articles. The titles and abstracts were each reviewed to identify those of interest for in-depth review. Eighty articles were retrieved, and their bibliographies were also reviewed to identify other potential articles for inclusion.

From 80 manuscripts, 11 met the inclusion criteria [2,8,9,11,17,24,33,34,37,38,39] and were then reviewed using a standard worksheet.[36] The worksheet uses evidence-based guidelines to assist in the systematic review of orthopedic literature. In addition to recording practical information, such as title, author, journal, citation, primary and secondary hypotheses, type of study, and results, the worksheet also assists in identifying and recording sources of bias, methods of randomization, follow-up, and other details important in assessing the methodologic design and identifying the level of evidence. Each of these 11 manuscripts was then reviewed in an evidence-based medicine journal club by 9 faculty members and fellows familiar with evidence-based medicine concepts.

The Methods and Results sections of these 11 manuscripts were then reviewed. Data regarding study demographics and methodology were extracted and placed in table form. Individual outcomes for pain, range of motion, strength, and function were catalogued. Outcomes were assessed for the effectiveness of each treatment over time (intragroup evaluation) and when different treatments were compared (between-group comparisons). Statistical outcomes were recorded when available. Clinical significance was found when statistical significance was $P < .05$ and the effect size or difference between treatments was 20% or more. Elements of the physical therapy programs used by each study were collected and divided into five major categories: range of motion, flexibility and stretching, strengthening techniques, therapist-driven manual therapy, modalities, and schedule, which were placed in table form. This information was used to develop a synthesized physical therapy program.

Results

Demographics

Patient demographics are summarized in Table I. Patient ages (range, 42-58 years) were typical for impingement syndrome.[32] Workers' compensation data were frequently missing, yet because these studies came from a number of different countries with different benefits and incentives for work-related injuries, these data may not translate across studies. The diagnosis of impingement in all 11 studies was made by physical examination using the impingement signs of Neer[32] or Hawkins,[18] or both. Confirmation with an impingement test, consisting of an injection of lidocaine in the subacromial space with elimination of the pain with the impingement sign,[32] was used in 5 studies.

Methodology

These 11 randomized trials were not without methodologic flaws (Table II). Randomization methods were described in 6 of the studies, 5 of which were ideal. Only 3 reported using blinded, independent examiners for follow-up data collection. Eleven studies used validated outcome measures. Brox et al[8,9] used a Neer shoulder score; however in 1993 when the study was done, this score was likely the best available. Follow-up was surprisingly good for 10 of the studies, and only 1 study[33] reported follow-up of less than 90%.

Components of the exercise programs

The components of the exercise programs had some variation, yet the general principles were seen throughout the different studies (Table III). These components included frequency, range of motion, stretching or flexibility, strengthening, manual therapy, modalities, and others. These data are reviewed later as the synthesized protocol is developed.

Exercise as a treatment for impingement

The data from this systematic review strongly suggest that exercise improves symptoms in patients with impingement syndrome (Tables IV-VII), a finding that agrees with other systematic reviews.[1,12,15,16] Supervised exercise, home exercise programs, exercise associated with manual therapy, and exercise after subacromial decompressions demonstrated improvements in pain in all but 1 study[11] (Table V). Statistical analysis comparing preexercise pain with postexercise pain was performed in 6 of the 11 studies. In 5 of 6 studies, exercise produced statistically significant and clinically significant reductions in pain.[2,9,24,35,38] Conroy et al[11] found significant improvements in pain when exercise was combined with manual therapy but not for exercise alone. Interestingly, they documented significant statistical and clinical improvements in range of motion for both groups.[11] It is important to note that this study followed up patients for only 3 weeks, which may have been responsible for the reduced effect of the treatment. Two studies used controls, either nontherapeutic laser treatment[8,9] or no treatment.[24] Both demonstrated statistically significant improvements in pain for exercise compared

Table I Patient demographics.

First author (year), country	Average age, year	Gender	Worker's Comp	Symptom duration	Diagnosis	How Dx made	Treatment groups
Bang (2000), USA	43	30M, 22F	NR	Group 1: 5.6 mons; Group 2: 4.4 mons	Impingement	Physical exam impingement signs	Group 1: Standard exercises Group 2: Standard exercises + manual therapy
Brox, (1993, 1999), Norway	48	66M, 59F	58% on sick leave	1-2 years	Impingement	Physical exam impingement signs and +impingement test	Group 1: Arthroscopic SAD + post-op supervised exercises Group 2: Supervised exercises Group 3: Placebo laser
Conroy (1998), USA	53	8M, 6F	NR	26 weeks	Impingement	Physical exam impingement signs	Group 1: Standard exercises Group 2: Standard exercises + manual therapy
Haahr (2005), Denmark	44.4	26M, 58F	73%	6 mons-3 years	Impingement	Physical exam impingement signs and +impingement test	Group 1: Physiotherapy treatments (19 sessions/12 weeks) Group 2: Arthroscopic SAD + post-op HEP
Ludewig (2003), USA	49	67 M, 0F	All M construction workers/claims NR	NR	Impingement ± biceps tendonitis	Physical exam impingement signs/biceps signs	Group 1: Instruction in HEP Group 2: No intervention
Peters (1997), Germany	58	46M, 26F	NR	>6 mons	Impingement	Physical exam impingement signs and +impingement test + ultrasound	Group 1: SAD (47% arthroscopic, 53% open) + post-op exercise program Group 2: Physical therapy
Rahme (1998), Sweden	42	19M, 23F	76% on sick leave	Almost 4 years	Impingement	Physical exam impingement signs and +impingement test	Group 1: Open SAD Group 2: Standard physiotherapy program
Senbursa (2007), Turkey	49	NR	NR	NR	Impingement	Physical exam impingement signs	Group 1: Instruction in HEP Group 2: HEP + manual and other therapy
Walther (2004), Germany	51	34M, 26F	NR	27.3 mons	Impingement	Physical examination, impingement signs and +impingement test, radiographs, ultrasound	Group 1: HEP Group 2: Supervised therapy Group 3: Functional brace
Werner (2002), Germany	52	20M, 20F	NR	27 mons	Impingement	Clinical findings, radiographs, ultrasound	Group 1: HEP Group 2: Supervised therapy

F, Female; *HEP,* home exercise program; *M,* male, *NR,* not reported; *SAD,* subacromial decompression; *USA,* United States of America.

Table II Study methodology

First author (year)	No.	Randomization method	Independent examiner	Outcomes of interest	Follow-up	Follow-up %
Bang (2000)	52	NR	Yes	Pain VAS [a] Strength Perception of function Functional Assessment Questionnaire[a]	60 days	96%
Brox (1993, 1999)	125	Random permuted blocks	Yes	Neer Shoulder Score Pain Scale 1-9 Emotional Distress on Hopkins Scale [a]	3 and 6 mons (1993) and 2.5 years (1999)	90% at 2.5 y
Conroy (1998)	14	NR	Yes	Pain VAS [a] Impingement Signs AROM Functional Skills	3 weeks	93%
Haahr (2005)	90	Sealed envelope	No	Constant Score[a] Pain VAS[a] Function	12 mons	91%
Ludewig (2003)	67	Investigator blindly selected 1 of 2 slips of paper	NR	Shoulder Rating Questionnaire SPADI[a]	10 weeks	92%
Peters (1997)	72	NR	No	Modified Constant Score[a]	1, 2, 3, and 4 years	86% for 1 y; 67% for 4 years
Rahme (1998)	42	Blocked randomization	NR	Pain VAS[a] Pain with two maneuvers	1 year	93%
Senbursa (2007)	30	NR	NR	Pain VAS[a] ROM Functional Assessment Questionnaire	4 weeks	100%
Walther (2004)	60	NR	NR	Constant Score[a] Pain VAS[a]	6 and 12 weeks	NR 100%?
Werner (2002)	40	Drawing lots	NR	Constant Score[a] Pain Score Function Score Movement Score	6 and 12 weeks	NR 100%?

AROM, active range of motion; *NR*, not reported; *ROM*, range of motion; *SPADI*, Shoulder Pain and Disability Index; *VAS*, visual analog scale.
[a] Outcomes of interest that have been validated.

with control groups. The difference in effect size for the Ludewig et al[24] cohort was only 15%, which did not reach our definition of clinical significance.

Other outcome parameters

Strength was not shown to improve significantly for exercise alone[2,17,38] but did improve when exercise was combined with manual therapy in 1 study[2] (Table VI).

Function improved with exercise in most studies[2,11,17,24,33] (Table VII), a finding that was statistically significant in the 4 studies that analyzed their results. These improvements were clinically significant in 2 of these studies.[2,11] Interestingly, Brox et al[9] reported reduced functional status in a group that underwent supervised exercise.

These results suggest that exercise therapy is highly effective at reducing pain and likely effective at improving function. These effects may be augmented with manual therapy or acromioplasty.

Home vs supervised exercise

Two studies compared the effects of supervised physical therapy with a home exercise program.[38,39] Although both groups improved, neither study could demonstrate statistically significant differences between the 2 exercise methods. No prestudy power analysis was described, and as

Table III Components of the exercise programs in the various studies

First author (year)	Frequency	Range of motion	Stretching/ flexibility	Strengthening	Joint mobilization/ manual therapy	Modalities	Other
Bang (2000)	2×/wk for 3 wks	NR	1.Anterior shoulder corner stretch	Elastic band: 3 sets of 10 reps	Study group received manual therapy techniques specifically applied to movement limitations in the upper quarter involving the shoulder and spine	NR	NR
			2.Posterior shoulder crossed body adduction stretch Each stretch hold 30 secs with 10-sec rest, repeat 3×	1.Flexion 2. Scaption 3. Rowing 4. Horizontal extension-external rotation 60-sec rest between sets 5. Seated press up 6. Elbow push-up + 25 reps or to fatigue			
Brox (1993)	Daily: supervised 2×/wk with unsupervised other days at home. Training continued 3-6 mons.	To eliminate gravitational forces and start the exercises the arm was suspended in a sling fixed to the roof. Relaxed repetitive movements (first rotation, then flexion-extension, and finally abduction-adduction) were performed for about an hour in daily training sessions.	NR	"Resistance was gradually added to strengthen the short rotator and the scapular stabilizing muscles"	NR	NR	"Three lessons on the anatomy and function of the shoulder, pain management, and ergonomics"

(*continued on next page*)

Table III (*continued*)

First author (year)	Frequency	Range of motion	Stretching/ flexibility	Strengthening	Joint mobilization/ manual therapy	Modalities	Other
Conroy (1998)	Supervised 3×/wk for 3 wks; instructions to exercise at home 3×/d.	Pendulum exercise and postural correction with pain free range	Cane-assisted flexion and external rotation, towel-assisted internal rotation, and noninvolved arm-assisted horizontal adduction	1. Chair press 2. Internal and external rotation isometrics 3. Exercises to restore synchronous scapulohumeral rhythm	Study group received 15 min of joint mobilization styled after Maitland and Foley, with inferior glide, anterior glide, posterior glide, long axis traction, oscillatory pressure	Hot packs for 15 min	Soft tissue mobilization at end of treatment for 10 min; patient education
Haahr (2005)	3×/wk for 2 wks then 2×/wk for 3 weeks then 1×/wk for 7 wks with daily active home exercises then home program 2-3×/wk	Active training of periscapular muscles (rhomboid, serratus, trapezoid, levator scapulae, and pectoralis minor muscles)	NR	Strengthening of the stabilizing muscles of the shoulder (the rotator cuff)	NR	Heat, cold packs	
Ludewig (2003)	Home therapy instruction. Daily home stretching, strengthening 3×/wk.	A muscle relaxation exercise for upper trapezius. Patient raises arm over head in scapula plane without shrugging. Performed in front of mirror or by holding upper trapezius with opposite hand	Corner stretch for pectoralis minor, crossed body adduction for posterior shoulder. Hold 30 secs, 5×/ stretch/d	1.Supine protraction of the scapula with hand weight	NR	NR	NR

(*continued on next page*)

Table III (*continued*)

First author (year)	Frequency	Range of motion	Stretching/ flexibility	Strengthening	Joint mobilization/ manual therapy	Modalities	Other
				2. Humeral external rotation with TheraBand, starting with arm close to body and increasing abduction angle over time. 3× 10 reps for wk 1, 3× 15 reps for wk 2, 3× 20 reps for wk 3, then increase resistance			
Peters (1997)	2 weeks intensive physical therapy and instruction in home program	Normalization of muscle tension, lifting arms without shrugging. Instruction in posture exercises and maintaining posture for activities of daily living	Improve mobility of adjacent joints. Stretch the posterior and anterior shoulder	Strengthen short rotators in pain-free region, strengthen scapular stabilizers	Manual therapy: pain traction, mobilization after relaxation therapy.	Ultrasound, iontophoresis, phonophoresis, heat	Muscle relaxation techniques, transverse friction massage, hydrotherapy, subacromial injectable steroids up to 3×
Rahme (1998)	2-3×/wk. Intervals between treatments were successively increased as the patient became more familiar with the object of the exercises	Unloaded movements of the shoulder. Measures to normalize the scapulohumeral rhythm and to increase postural awareness	NR	Strengthening the shoulder muscles and endurance training. Submaximal training of the rotator cuff	NR	NR	Information on functional anatomy and biomechanics of the shoulder. Advice on how to avoid positions for "wear and tear" of subacromial structures
Senbursa (2007)	Group 1: home program 7×/wk	Active ROM	Stretching	Strengthening of the rotator cuff muscles, rhomboids, levator scapulae, serratus anterior with elastic bands	Deep friction massage on supraspinatus, radial nerve stretching, scapular mobilization, glenohumeral joint mobilization	Ice	Proprioceptive neuromuscular facilitation including rhythmic stabilization and hold-relax

(*continued on next page*)

Table III (*continued*)

First author (year)	Frequency	Range of motion	Stretching/ flexibility	Strengthening	Joint mobilization/ manual therapy	Modalities	Other
	Group 2: Supervised exercises and manual therapy 3×/wk for 4 wks with home exercises						
Walther (2004)	Group 1: Home therapy—4 visits with therapist for instruction, 5×/wk for 10-15 mins	Pendulum exercises holding 1-kg hand weight for 3-5 mins	Lateral neck stretching, posterior shoulder stretch by pulling arm across front of body toward floor; hold stretch for 15 sec, repeat 3×	Isometric seated TheraBand exercises for pulling shoulder blades back, and downward; hold 8-10 sec; repeat 10×	NR	NR	Coopercare-Lastrap functional shoulder brace in one group
	Group 2: Supervised therapy 2-3×/wk			Seated TheraBand resisted humeral external rotation, upright rows; repeat 10× Standing TheraBand resisted shoulder extension; repeat 10×			
Werner (2002)	Group 1: Home therapy—4 visits for instruction, 5×/wk of 10-15 mins	Pendulum exercises holding 1-kg hand weight for 3-5 mins	Lateral neck stretching, posterior shoulder stretch by pulling arm across front of body toward floor. Hold stretch for 15 secs, repeat 3×	Isometric seated TheraBand exercises for pulling shoulder blades back, and downward; hold 8-10 secs; repeat 10×	NR	NR	NR
	Group 2: Supervised therapy—30 visits each lasting 30 mins over 12 wks with strengthening of the rotator cuff.			Seated TheraBand resisted humeral external rotation, upright rows; repeat 10× Standing TheraBand resisted shoulder extension; repeat10×			

NR, not reported; *ROM,* range of motion.

Table IV Outcomes for pain[a]

Author (year)	Outcome scale	Groups	Intragroup difference	Statistically significant	Clinically significant	Between-group difference	Statistically significant	Clinically significant?
Bang (2000)	9 pain-related questions, each with 100 mm VAS total pain score 0- 900 mm	Exercise	196.5	$P < .05$	Yes	204.9 (favors exercise + manual therapy)	$P < .05$	Yes
		Exercise + manual therapy	401.4	$P < .05$	Yes			
Brox (1993), 6-mon F/U	Component of NSP during previous week, 0-35 points; also RP, NP, and AP on 1-9 scale	Supervised exercises	(NSP) 10.0	(NSP) $P = .03$*	Yes	Supervised exercise vs SAD	NS	No
			(RP) 3.0 (NP) 2.0 (AP) 4.0	*Sex adjusted Other scores reported		(NSP) 0.0		
		Arthroscopic SAD with post-op exercise	(NSP) 10.0	(NSP) $P = .03$*	Yes	Supervised exercise vs placebo		
			(RP) 2.0 (NP) 2.0 (AP) 4.0	*Sex adjusted Other scores reported		(NSP) 10.0		
		Laser placebo	(NSP) 0.0 (RP) 0.5 (NP) 1.0 (AP) 1.0	NR	NA	SAD vs placebo (NSP) 10.0		
Brox (1999), 30-mon F/U	Patients (%) with >50% reduction in RP, NP, AP	Supervised exercises	(RP) 49%	NR	NA	Supervised exercise vs SAD	NS	No
			(NP) 51% (AP) 49%			~12% favoring SAD		
		Arthroscopic SAD with post-op exercise	(RP) 63%			Supervised exercise vs placebo ~28% favoring exercise	$P < .01$	Yes
			(NP) 63% (AP) 61%					
		Laser placebo	(RP) 21%			SAD vs placebo ~40% favoring SAD	$P = .001$	Yes
			(NP) 21%					

(*continued on next page*)

Table IV (*continued*)

Author (year)	Outcome scale	Groups	Intragroup difference	Statistically significant	Clinically significant	Between-group difference	Statistically significant	Clinically significant?
			(AP) 25%					
Conroy (1998)	Maximum pain over past 24 hours on 100 mm VAS	Exercises	2.21	$P = .823$	No	32.07 (favors exercise + manual therapy)	$P = .008$	Yes
		Exercises + manual therapy	20.7	$P = .005$	Yes			
Haahr (2005)	VAS part of CS, 0-15 mm	Exercises	3.7	NR	NA	0.1	$P = .93$	No
		Arthroscopic SAD	3.6					
Ludewig (2003)	VAS work-related pain score, 0-10	Exercise	2	$P < .001$	Yes	1.5	$P < .05$	No
		No intervention	0.5					
Peters (1997)	Pain score from Modified CS, 0-35 points	Exercise	5 at 1 year	No statistical analysis	NA	10 at 1 year	NR	NA
			0 at 4-years			20 at 2 years favoring surgery		
		SAD	15 at 1 year 20 at 4 years					
Rahme (1998)	VAS pain at rest + VAS pain lifting 1-L bottle with arm extended. Data presented as relative reduction in pain from pretreatment score	Exercise	33% had >50% pain reduction at 6 mons	Not assessed	NA	24% more patients had >50% pain relief favoring surgery group.	NS	NA
		SAD with post-op exercise	57% had >50% pain reduction at 6 mons					
Senbursa (2007)	Pain VAS, 100 mm	HEP	36	$P < .05$	Yes	11	$P = .05$	No
		HEP + manual therapy	47	$P < .05$	Yes			
Walther (2004)	VAS, 100 mm	HEP	"All three groups showed a significant reduction in their pain levels, at night as well as during rest periods and while under stress during the study"	$P < .05$	Yes for pain with load and at night, No for rest pain.	Minimal	NS	No

(*continued on next page*)

Table IV (*continued*)

Author (year)	Outcome scale	Groups	Intragroup difference	Statistically significant	Clinically significant	Between-group difference	Statistically significant	Clinically significant?
	Pain at rest, night, load recorded	Supervised exercises						
		Brace						
Werner (2002)	Component of CS, 0-35 points	HEP	Approx 9-point improvement	No statistical analysis	NA	Minimal differences between groups	NR[b]	NA
		Supervised therapy	Approx 8-point improvement					

AP, activity pain; *CS*, Constant Score, *F/U*, follow-up; *HEP*, home exercise program; *NA*, not applicable; *NP*, night pain; *NR*, not reported; *NS*, not significant; *NSP*, Neer scale for pain; *RP*, rest pain; *SAD*, subacromial decompression, *VAS*, visual analog scale.

[a] Authors used a variety of scales to measure pain. Intragroup differences detect the effect of the particular protocol over time and compare pretreatment with status at follow-up. Between-group differences are reported for differences between the different protocols. Clinically significant findings occur if the differences are statistically significant and the magnitude of the difference is 20% or more.

[b] "Statistically the differences between the individual components (of the Constant Score) were not different between the two groups." No *P* values given.

such, this finding may be the result of a type II statistical error.

Manual therapy

The effect of manual therapy (joint and soft tissue mobilization) was evaluated in 3 studies.[2,11,35] In each study, pain relief was statistically better when patients received manual therapy. In 2 of the studies, the effect size was clinically significant[2,11]; in the other,[35] the difference in the effect size was 11%, which did not reach clinical significance.

Bracing

One study[38] evaluated bracing without exercise. The authors chose a functional shoulder brace that is indicated for the treatment of chronic tendinitis or bursitis. The patients randomized to the brace group had significant improvements in pain over time, with outcomes that were statistically indistinguishable from the home exercise and supervised exercise groups. Results for strength were significantly and clinically better for the brace group compared with the 2 exercise groups.[38]

Acromioplasty with exercise vs exercise alone

Four in 5 reports compared acromioplasty with exercise vs exercise alone.[8,9,17,33,34] All studies failed to show statistically significant differences between the 2 treatments. Rahme et al[34] reported that after 6 months, 12 of 21 patients (57%) randomized to the exercise group opted for surgery and were considered failures of nonoperative treatment. Brox et al[8] followed up their cohort for 2.5 years and found 11 of 50 patients (22%) randomized to the exercise treatment alone ultimately came to surgery and were considered failures.

Discussion

This systematic review of randomized controlled trials evaluates the best evidence for the role of exercise in the treatment of rotator cuff impingement syndrome. The general findings from this study are:

1. exercise is effective as a treatment for the reduction of pain,
2. home exercise programs may be as effective as supervised exercise, yet
3. the effect of exercise may be augmented with manual therapy,
4. acromioplasty with postoperative exercise also produces improvements in symptoms, and
5. there may be a role for bracing; however, this interesting approach requires further study.

Table V Range of motion outcomes[a]

Author	Outcome scale	Groups	Intragroup difference	Statistically significant	Clinically significant	Between-group difference	Statistically significant	Clinically significant
Bang (2000)	NA	NA	NA	NA	NA	NA	NA	NA
Brox (1993)	ROM score part of Neer score, 0-25 points	Supervised exercises	NR	NA	NA	NR	NA	NA
		Arthroscopic SAD with post-op exercise						
		Laser placebo						
Brox (1999)	ROM score part of Neer score, 0-25 points	Supervised exercises	NR	NA	NA	NR	NA	NA
		Arthroscopic SAD with post-op exercise						
		Laser placebo						
Conroy (1998)	ABD, EL, ER, IR measured in degrees	Exercise	Both groups significantly improved, data combined	Each ROM measure	Yes	Differences in all planes $<8^{\circ}$, but all favored exercise alone group	No	No
			ABD = 27	$P < .0095$				
			EL = 24					
			ER = 14					
		Exercise + manual therapy	IR = 14					
Haahr (2005)	Subscore of CS	Exercise	11.6	NR	NA	3.4 (favors e xercise group)	$P = .17$	No
	0-40 points	Arthroscopic SAD	8.2					
Ludewig (2003)	NA	NA	NA	NA	NA	NA	NA	NA
Peters (1997)	Subscore of Modified CS	Exercise	0 at 1 year	No statistical analysis	NA	10 points at 1 and 4 years favoring surgery	No statistical analysis	NA
	0-35 points		0 at 4 years					
		SAD	10 at 1 year					
			10 at 4 years					
Rahme (1998)	NA	NA	NA	NA	NA	NA	NA	NA

(*continued on next page*)

Table V (*continued*)

Author	Outcome scale	Groups	Intragroup difference	Statistically significant	Clinically significant	Between-group difference	Statistically significant	Clinically significant
Senbursa (2007)	ROM measured with goniometer in flexion, ABD, ER, and IR	HEP	"Range of motion at flexion, abduction and external rotation in the manual therapy group improved significantly while ROM in the exercise group did not"	No	No data available	NA	NA	NA
		HEP with manual therapy		$P < .05$				
Walther (2004)	Component of CS,. 0-40 points	HEP	All improved approximately 4 points	NR	NA	Minimal differences between groups	NS	No
		Supervised therapy						
		Brace						
Werner (2002)	Component of CS, 0-40 points	HEP	Approx 5-point improvement	No statistical analysis	NA	Minimal differences between groups	Not different[b]	NA
		Supervised therapy	Approx 2-point improvement					

ABD, abduction; *CS,* Constant Score, *EL,* elevation, *ER,* external rotation; *HEP,* home exercise program; *IR,* internal rotation; *NA,* not assessed; *NR,* not reported; *ROM,* range of motion; *SAD,* subacromial decompression.

[a] Range of motion data are lacking in most studies. Intragroup differences detect the effect of the particular protocol over time and compare pretreatment with status at follow-up. Between-group differences are reported for differences between the different protocols. Clinically significant findings occur if the differences are statistically significant and the magnitude of the difference is 20% or more.

[b] "Statistically the differences between the individual components (of the Constant Score) were not different between the two groups."

No *P* values given.

Table VI Outcomes-strength[a]

Author	Outcome scale	Groups	Intragroup difference	Statistically significant	Clinically significant	Between-group difference	Statistically significant	Clinically significant
Bang (2000)	Abduction, external rotation, internal rotation composite score (Newtons, N)	Exercise	24.8 N	No	No	A significant difference existed pretreatment favoring exercise + manual therapy group rendering posttreatment comparisons meaningless	NA	NA
		Exercise + manual therapy	93.0 N	$P < .05$	No			
Brox (1993)	NA	Supervised exercises Arthroscopic SAD Laser placebo	NA	NA	NA	NA	NA	NA
Brox (1999)	NA	Supervised exercises Arthroscopic SAD Laser placebo	NA	NA	NA	NA	NA	NA
Conroy (1998)	NA	NA	NA	NA	NA	NA	NA	NA
Haahr (2005)	Subscore of CS, 0-25 points	Exercise	3.2	NR	NA	0.1 (favors surgery)	$P = .96$	No
		Arthroscopic SAD	3.3					
Ludewig (2003)	NA	NA	NA	NA	NA	NA	NA	NA
Peters (1997)	NA	NA	NA	NA	NA	NA	NA	NA
Rahme (1998)	NA	NA	NA	NA	NA	NA	NA	NA
Senbursa (2007)	NA	NA	NA	NA	NA	NA	NA	NA
Walther (2004)	Subset of CS	HEP	0.1	NR	NA	4.0 (favoring brace vs supervised therapy)	HEP vs supervised exercise; NS	Yes
	0-20 points	Supervised therapy	−1.4				Brace vs other treatments, $P < .05$	
		Brace	2.6					
Werner (2002)	NA	NA	NA	NA	NA	NA	NA	NA

CS, Constant Score; *HEP,* home exercise program; *NA,* not assessed; *NR,* not reported; *NS,* not significant; *SAD,* subacromial decompression.

[a] Strength was measured in 1 study and the strength subset of the Constant Score was used in two others. Walther et al[38] found that wearing a brace improved strength more than exercise, an effect that was statistically and clinically significant. Intragroup differences detect the effect of the particular protocol over time and compare pretreatment with status at follow-up. Between-group differences are reported for differences between the different protocols. Clinically significant findings occur if the differences are statistically significant and the magnitude of the difference is 20% or more.

Table VII Outcomes—function[a]

Author	Outcome Scale	Groups	Intragroup difference	Statistically significant	Clinically significant	Between-group difference	Statistically significant	Clinically significant
Bang (2000)	Functional Assessment Questionnaire, 9 questions, 5 points each, 45 points total	Exercise	4.74	$P < .05$	No	4.96 (favoring manual therapy)	P < .0893	No
		Exercise + manual therapy	9.89	$P < .05$	Yes		No	
Brox (1993)	Subset of Neer score, 0-30 points	Supervised exercises	-6	NR	NA	10.0 (Favoring SAD)	NR	NA
		Arthroscopic SAD + exercise	4					
		Laser placebo	1					
Brox (1999)	% of patients who could: Carry 5 kg at side/and take down something from wall cupboard	Supervised exercises	47% and 41%	NR	NA	Supervised Exercise vs SAD	Take down from cupboard, P < .05	Yes
						14% and 25% favoring SAD		
		Arthroscopic SAD + exercise	61% and 66%			Supervised exercise vs placebo 29% and 16% favoring exercise	P < .01	Yes
		Laser placebo	18% and 25%			SAD vs placebo 43% and 41% favoring SAD	P < .001	Yes
Conroy (1998)	Nonvalidated questionnaire re ability to reach in 3 planes	Exercise	Both groups significantly improved, data combined; ~1/2 patients reported improvements in reaching behind head, reaching overhead, reaching to spinous process	$P < .038$	Yes	No differences between groups	No	No
		Exercise + manual therapy						
Haahr (2005)	Subset of CS, 0-20 points	Exercise	4.5	NR	NA	0.7 (favoring exercise group)	P = .46	No

(*continued on next page*)

Table VII (*continued*)

Author	Outcome Scale	Groups	Intragroup difference	Statistically significant	Clinically significant	Between-group difference	Statistically significant	Clinically significant
		Arthroscopic SAD + exercise	3.8					
Ludewig (2003)	Work Related Disability VAS, 0-10 points	Exercise	1.6	$P < .001$	No	1.5 (favoring exercise group)	$P < .05$	No
		No intervention	0.1					
Peters (1997)	Activity Score from Modified CS, 0-10 points	Exercise	0 at 1 year	No statistical analysis	NA	2 points at 1 year	No statistical analysis	NA
			0 at 4 years			2 points at 4 years		
		SAD + exercise	2 at 1 year					
			2 at 4 years					
Rahme (1998)	NA	NA	NA	NA	NA	NA	NA	NA
Senbursa (2007)	Neer Functional Assessment Questionnaire	HEP	NR	NR	NA	"There were statistically significant differences among the groups in function" (favoring HEP + manual therapy)	$P < .05$	Unknown, data not reported
		HEP + manual therapy						
Walther (2004)	NA	NA	NA	NA	NA	NA	NA	NA
Werner (2002)	NA	NA	NA	NA	NA	NA	NA	NA

CS, Constant Score; *HEP*, home exercise program; *NA*, not assessed; *NR*, not reported; *SAD*, subacromial decompression; *VAS*, visual analog scale.

[a] Function was assessed in a variety of ways. Intragroup differences detect the effect of the particular protocol over time and compare pretreatment to status at follow up. Between-group differences are reported for differences between the different protocols. Clinically significant findings occur if the differences are statistically significant and the magnitude of the difference is 20% or more.

Interestingly, each study had variations in the components of the physical therapy program, and as a result, there was a substantial amount of variation in the effectiveness of the individual programs. In studies evaluating patients with rotator cuff disease, the physical therapy protocol represents a critical confounding variable; which, if not controlled, may have a substantial effect on outcome and then serve as a source of performance bias.

This supports the development of a gold standard rehabilitation protocol. The utility of a standardized, accepted, evidence-based rehabilitation protocol for treating rotator cuff impingement is apparent. First, physicians and therapists will know that their patients are receiving the best available rehabilitation program that has the greatest likelihood of improving the patient's condition and avoiding surgery. Second, an accepted gold standard rehabilitation protocol would reduce confounding variables and performance bias in research studies. This will allow comparison of results between studies. A gold standard protocol would also serve as a control allowing the study of modifications, such as modalities, adding exercises or other treatments, eliminating specific components, and clarifying the effect of the investigated treatment. To assist with this, we synthesized the protocols described in these reviewed articles to develop a standard rehabilitation protocol.

Data from the rehabilitation protocols used in these articles were compiled in table format (Table III). Information about specific components was extracted, including frequency, range of motion, flexibility, strengthening, manual therapy, and modalities, and then synthesized into a comprehensive protocol (Appendix I).

Different authors had their patients perform exercises at different frequencies, ranging from twice weekly[2] to daily.[8,9,24,35] Some authors used supervised therapy with greater frequency early, progressing toward home exercises later.[17,34]

On the basis of this information, we suggest that patients have supervised therapy 2 to 3 times each week, with the addition of manual therapy (see subsequent text). Patients who no longer need manual therapy and have developed proficiency in the protocol can be progressed to a home exercise program. Range of motion exercises and flexibility should be performed daily. Strengthening should be performed 3 times weekly.

Range of motion exercises were described by most authors. Pendulum exercises were used in the cohorts of Conroy et al,[11] Walther et al,[38] and Werner et al.[39] Postural exercises, such as shrugs, were used by Conroy el al,[11] Peters et al,[33] and Rahme et al.[34] Active assisted range of motion was described with a cane,[11] with the arm suspended,[8,9] or with the other arm.[24] Brox et al[8,9] recommended active assisted motion with the arm suspended in a sling for rotation, flexion-extension, and abduction-adduction. Ludewig et al[24] had patients stand before a mirror and work on shoulder elevation without shrugging. If a mirror was not available, they had the patient place the uninvolved hand on the contralateral trapezius to provide feedback, making sure the upper trapezius remained relaxed during elevation of the arm.[24] Haahr et al[17] described active training of the periscapular muscles (rhomboid, serratus, trapezoid, levator, and pectoralis minor).

The conclusion from this information is that all patients may begin their range of motion work with postural exercise, such as shrugs, and shoulder retraction. Glenohumeral motion should begin with pendulum exercises, progress to active assisted motion, then to active motion as comfort dictates. Active assisted motion may be performed with a cane, suspended with pulleys, or with the uninvolved arm. Active motion may be performed in front of a mirror or using the opposite hand on the trapezius to prevent hiking of the shoulder, as described by Ludewig et al.[24]

Flexibility exercises generally were performed for anterior and posterior shoulder tightness.[2,11,24,38,39] In addition, Conroy et al[11] had patients perform cane-assisted stretching in flexion and external rotation. A variety of techniques were described for posterior shoulder stretching, most commonly cross-body adduction.[2,11,24,38,39] Interestingly, McClure et al[27] conducted a randomized trial comparing 2 different techniques to stretch the posterior shoulder—the sleeper stretch and the cross-body stretch—and found that the cross-body stretch was most effective.[27] With regard to anterior shoulder stretching, Borstad et al[5] performed a randomized trial of 3 stretches designed to stretch the pectoralis minor, consisting of unilateral self-stretch, supine manual stretch, and sitting manual stretch. Although all patients demonstrated gains in pectoralis minor length, they found the unilateral self-stretch (performed in a corner or on a door jamb) produced the greatest effect.[5] Most authors recommended holding each stretch for 15 or 30 seconds and repeating 3 to 5 times, with a 10-second rest between each stretch.[2,24,38,39]

These data indicate that stretching should be performed daily and should include anterior shoulder stretching, performed by the patient in a corner or door jamb, and posterior shoulder stretching, using the cross-body adduction technique. Each stretch should be held for 30 seconds and repeated 5 times, with a 10-second rest between each stretch. Cane stretching in forward elevation and external rotation may also be used in a similar fashion.

Some authors did not provide much detail regarding their programs for strengthening, other than reporting that muscles of the rotator cuff and scapula stabilizers were involved.[17,34,35] Others were more specific in describing their exercise programs. For example, strengthening exercises include shoulder flexion,[2] extension,[38,39] scaption,[2] rows,[2,38,39] internal rotation of the adducted arm,[2,11,24] and external rotation of the adducted arm.[2,11,24,38,39]

Most authors used elastic bands.[2,24,35,38,39] Most allowed joint movement for isotonic exercise[2,24,35]; others relied on static resistance with isometric muscle contraction.[11,38,39]

Each exercise was performed at 3 sets of 10 repetitions with a 60-second rest between each set[2] or 3 sets of 10 the

first week, followed by 3 sets of 15 the second week, followed by 3 sets of 20 the third week; then increasing TheraBand (Hygenic Corp, Akron, OH) resistance was used.[24]

Scapular stabilizing exercises included the seated press up[2,11] and the elbow push-up plus[2] and were performed on a chair or stable bench. Each was performed as 1 set of 25 repetitions.[2] Supine push-up plus with a hand weight was used by Ludewig et al.[24]

The synthesis of these reports clearly shows that strengthening exercises should focus on the rotator cuff and scapular stabilizing muscles. Rotator cuff strengthening should involve the following exercises with the TheraBand: internal rotation with arm adducted to side, external rotation with arm adducted to side, and scaption, if there is no pain associated with the exercise. Scapular stabilizer strengthening should include chair press, push-up plus (prone using body weight or supine with hand weight), and upright rows using an elastic band. Combination strengthening while standing using elastic bands should include forward elevation and extension. Each exercise should be performed as 3 sets of 10 repetitions, with increases in elastic resistance as strength improves.

Manual therapy has been shown to be effective at augmenting the effect of exercise in relieving symptoms of the impingement syndrome.[2,11,35] Manual therapy includes a variety of techniques, including joint mobilization, as described by Maitland[25] and Foley et al,[14] and soft tissue mobilization (effleurage, friction, and kneading techniques).[11,17]

Because the evidence favors the use of manual therapy, it should be included in a standard evidence-based protocol. Like exercise, the different varied aspects of manual therapy are worthy of further study to identify which components are effective in treatment. Manual therapy requires working with a physical therapist. During the period that patients are receiving manual therapy, they should be thoroughly instructed in the exercise program. Patients who no longer need manual therapy should be progressed to a home exercise program.

Ultrasound as a therapeutic modality has been evaluated by a number of studies. It is beyond the scope of this review to evaluate the effectiveness of ultrasound; however, multiple systematic reviews state that ultrasound is of little value in treating patients with shoulder pain.[16,28,37] Conroy et al[11] and Haahr et al[17] both used heat in their protocols. Haahr et al[17] and Senbursa et al[35] used ice. There are no data for or against the use of cold or heat as a modality; thus, their use must be optional at this point. It is clear, however, that ultrasound has no value in a rehabilitation protocol for the impingement syndrome.

With this information we offer a gold standard rehabilitation protocol (Appendix I). It is important to recognize that this evidence-based protocol is not without limitations. The protocol described is a collection of features that have demonstrated a reduction in symptoms for impingement syndrome in randomized controlled trials. Some components in these studies may be unnecessary. Other features, which may be beneficial, may not be included. This may be reflective of another limitation of this study; namely, the diagnosis of impingement syndrome is based on a provocative test designed to produce pain in the subacromial space.[32] The Neer impingement sign[32] and the Hawkins impingement sign[18] may be imperfect tools to diagnose rotator cuff disease because they both have relatively poor specificities.[19]

It could be argued that impingement syndrome is not a diagnosis at all; but rather, is the finding of a provocative physical examination test that could be produced by a variety of subacromial pathologies, including subacromial bursitis, bursal sided partial rotator cuff tears, biceps tendinitis, scapular dyskinesis, a tight posterior capsule, and postural abnormalities, among others. As a result, the protocol proposed in this article may need modifications to make it specific to a particular patient's anatomic diagnosis. For example, it may not be applicable to an athlete with rotator cuff pain due to excessive laxity in the shoulder. In addition, this protocol cannot be extrapolated to the postoperative state, where the clinicians may be interested in protecting a healing rotator cuff.

Despite these limitations, this systematic review of the best available evidence for exercise in the treatment of impingement syndrome was able to generate a physical therapy protocol that has been shown to be effective in level 1 and level 2 studies. This evidence-based protocol can be used by clinicians treating impingement syndrome and can serve as a gold standard to reduce variables in future cohort and comparative studies to help find better treatments for patients with this disorder.

Acknowledgments

Thanks to members of the Vanderbilt Sports Medicine Journal Club who assisted in reviewing the articles: Kurt Spindler, Warren Dunn, Buddy Hannah, Andrew Gregory, Paul Rummo, Tara Holmes, Mick Koester, and Kevin Doulens.

References

1. Ainsworth R, Lewis JS. Exercise therapy for the conservative management of full thickness tears of the rotator cuff: a systematic review. Br J Sports Med 2007;41:200-10.
2. Bang M, Deyle G. Comparison of supervised exercise with and without manual physical therapy for patients with impingement syndrome. J Ortho Sports Phys Ther 2000;30:126-37.
3. Bennell K, Coburn S, Wee E, et al. Efficacy and cost-effectiveness of a physiotherapy program for chronic rotator cuff pathology: a protocol for a randomised, double-blind, placebo-controlled trial. BMC Musculoskelet Disord 2007;8:86.
4. Bohmer AS, Staff PH, Brox JI. Supervised exercises in relation to rotator cuff disease (impingement syndrome stages II and III): a treatment regimen and its rationale. Physiother Theory Pract 1998;14:93-105.

5. Borstad JD, Ludewig PM. Comparison of three stretches for the pectoralis minor muscle. J Shoulder Elbow Surg 2006;15:324-30.
6. Brewster C, Schwab DR. Rehabilitation of the shoulder following rotator cuff injury or surgery. J Orthop Sports Phys Ther 1993;18:422-6.
7. Browning DG, Desai MM. Rotator cuff injuries and treatment. Prim Care Clin Office Pract 2004;31:807-29.
8. Brox JI, Gjengedal E, Uppheim G, et al. Arthroscopic surgery versus supervised exercises in patient with rotator cuff disease (stage II impingement syndrome): A prospective, randomised, controlled study in 125 patients with a 2 ½ year follow-up. J Shoulder Elbow Surg 1997;8:102-11.
9. Brox J, Staff P, Ljunggren A, Brevik J. Arthroscopic surgery compared with supervised exercises in patients with rotator cuff disease. BMJ 1993;307:899-903.
10. Cakmak A. Conservative treatment of subacromial impingement syndrome. Acta Orthop Traumatol Turc 2003;37(Suppl 1):112-8.
11. Conroy DE, Hayes KW. The effect of mobilization as a component of comprehensive treatment for primary shoulder impingement syndrome. J Ortho Sports Phys Ther 1998;28:3-14.
12. Desmeules F, Cote CH, Fremont P. Therapeutic exercise and orthopaedic manual therapy for impingement syndrome. A systematic review. Clin J Sports Med 2003;13:176-82.
13. Ellenbecker TS, Derscheid GL. Rehabilitation of overuse injuries of the shoulder. Clin Sports Med 1989 Jul;8:583-604.
14. Foley R, Janos S, Johnson R, Petersen C. Active and passive movement testing of the extremities, spine, pelvis, and temporomandibular joint. In: Petersen C, editor. Teaching manual for physical therapy. Chicago: Northwestern University, Department of Physical Therapy and Human Movement Sciences; 1994. p. 34−68.
15. Grant HJ, Arthur A, Pichora DR. Evaluation of interventions for rotator cuff pathology: a systematic review. J Hand Ther 2004;17:274-99.
16. Green S, Buchbinder R, Hetrick S. Physiotherapy interventions for shoulder pain. Cochrane Database Syst Rev 2003;2. CD004258.
17. Haahr JP, Ostergaard S, Dalsgaard J, Norup K, Frost P, Lausen S, et al. Exercises versus arthroscopic decompression in patients with subacromial impingement: a randomised, controlled study in 90 cases with a one year follow up. Ann Rheum Dis 2005;64:760-4.
18. Hawkins RJ, Kennedy JC. Impingement syndrome in athletes. Am J Sports Med 1980;8:151-8.
19. Hegedus EJ, Goode A, Campbell S, et al. Physical examination tests of the shoulder: a systematic review with meta-analysis of individual tests. Br J Sports Med 2008;42:80-92.
20. Jobe FW, Moynes DR. Delineation of diagnostic criteria and a rehabilitation program for rotator cuff injuries. Am J Sports Med 1982;10: 226-9.
21. Kibler WB, McMullen J, Uhl T. Shoulder rehabilitation strategies, guidelines, and practice. Orthop Clin North Am 2001;32:527-38.
22. Kibler WB. Rehabilitation of rotator cuff tendinopathy. Clin Sports Med 2003;22:837-47.
23. Krabak BJ, Sugar R, McFarland EG. Practical nonoperative management of rotator cuff injuries. Clin J Sport Med 2003;13:102-5.
24. Ludewig PM, Borstad JD. Effects of a home exercise programme on shoulder pain and functional status in construction workers. Occup Environ Med 2003;60:841-9.
25. Maitland G. *Peripheral manipulation*. London, UK: Butterworth-Heinmann Ltd; 1991. 47−52, 129-67.
26. Mantone JK, Burkhead WZ Jr, Noonan J Jr. Nonoperative treatment of rotator cuff tears. Orthop Clin North Am 2000;31:295-311.
27. McClure P, Balaicuis J, Heiland D, Broersma ME, Thorndike CK, Wood A. A randomized controlled comparison of stretching procedures for posterior shoulder tightness. J Orthop Sports Phys Ther 2007;37:108-14.
28. Michener LA, Walsworth MK, Burnet EN. Effectiveness of rehabilitation for patients with subacromial impingement syndrome: a systematic review. J Hand Ther 2004;17:152-64.
29. Millett PJ, Wilcox RB III, O'Holleran JD, Warner JJP. Rehabilitation of the rotator cuff: an evaluation-based approach. J Am Acad Ortho Surg 2006;14:599-609.
30. Morrison DS, Frogameni AD, Woodworth P. Conservative management for subacromial impingement syndrome. J Bone Joint Surg Am 1997;79:732-7.
31. Morrison DS, Greenbaum BS, Einhorn A. Shoulder impingement. Orthop Clin North Am 2000;31:285-93.
32. Neer CS 2nd. Impingement lesions. Clin Orthop Relat Res 1983:70-7.
33. Peters G, Kohn D. Medium-tern clinical results after operative and non-operative treatment of subacromial impingement. Unfallchirurg 1997;100:623-9.
34. Rahme H, Solem-Bertoft E, Westerberg CE, Lundberg E, Sorensen S, Hilding S. The subacromial impingement syndrome. A study of results of treatment with special emphasis on predictive factors and pain-generating mechanisms. Scand J Rehab Med 1998;30:253-62.
35. Senbursa G, Baltaci G, Atay A. Comparison of conservative treatment with and without manual physical therapy for patients with shoulder impingement syndrome: a prospective, randomized clinical trial. Knee Surg Sports Traumatol Arthrosc 2007;15:915-21.
36. Spindler KP, Kuhn JE, Dunn W, Matthews CE, Harrell FE Jr, Dittus RS. Reading and reviewing the orthopaedic literature: a systematic, evidence-based medicine approach. J Am Acad Orthop Surg 2005;13:220-9.
37. Van Der Heijden GJ. Physiotherapy for patients with soft tissue disorders: a systematic review of randomized clinical trials. BMJ 1997;315:25-30.
38. Walther M, Werner A, Stahlschmidt T, Woeffel R, Gohlke F. The subacromial impingement syndrome of the shoulder treated by conventional physiotherapy, self-training, and a shoulder brace: results of a prospective, randomized study. J Shoulder Elbow Surg 2004;13: 417-23.
39. Werner A, Walther M, Ilg A, Stahlschmidt T, Gohlke F. Self-training versus conventional physiotherapy in subacromial impingement syndrome [German]. Z Orthop Ihre Grenzgeb 2002;140:375-80.

Appendix I Evidence-based medicine exercise protocol for impingement syndrome

General instructions: This physical therapy protocol is based on the best evidence demonstrating a beneficial effect for exercise in the treatment of rotator cuff tendonitis. It is largely unknown if adding or eliminating exercises will affect the outcome. Range of motion and stretching exercises should be performed daily. Strengthening should be performed 3 times weekly.

Modalities: Heat or cold, or both, may be used. Studies have demonstrated that the results of ultrasound treatment are no better than results in control patients, and it should not be used.

Manual therapy: Joint and soft tissue mobilization techniques have been shown to augment the effect of the exercise program. Initially, supervised exercises with manual therapy are recommended. During that time patients, should be instructed in a home program. Patients can move entirely to a home program when they no longer are in need of manual therapy.

Range of motion (Figures A1, A2, A3, A4, A5): Patients may begin their range of motion work with postural exercise such as shrugs and shoulder retraction. Glenohumeral motion should begin with pendulum exercises, progress to active assisted motion, then to active motion as comfort dictates. Active assisted motion may be

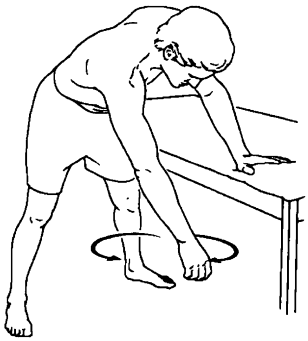

Figure A1 Pendulum exercises: Let the arm dangle. Make 20 small counterclockwise circles. Make 20 small clockwise circles. Make forward and backward motions, then side to side motions.

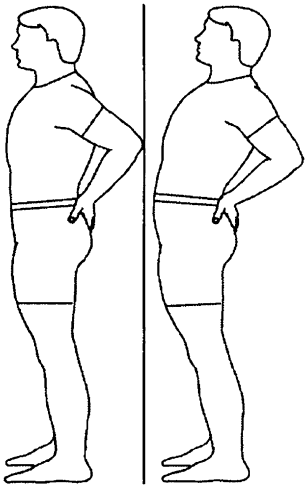

Figure A2 Posture exercises: Put hands on the hips, lean back, and hold.

performed with a cane, suspended with pulleys, or the uninvolved arm. Active motion may be performed in front of a mirror or using the opposite hand on the trapezius to prevent hiking of the shoulder.

Flexibility (Figures A6 and A7): Stretching should be performed daily and should include anterior shoulder

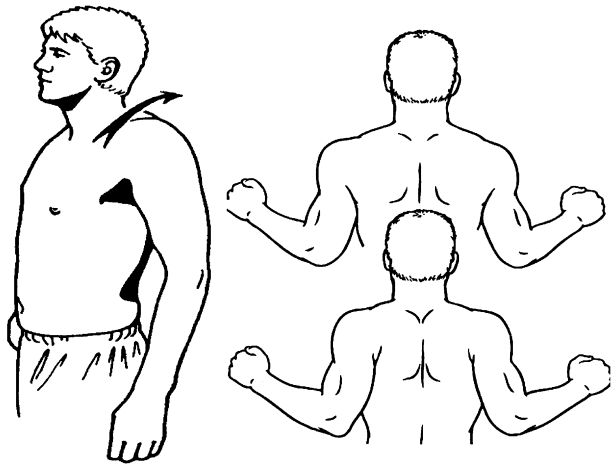

Figure A3 Active training of the scapula muscles. **(Left)** Shoulder shrugs: Pull the shoulders up and back, and hold. **(Right)** Pinch the back of the shoulder blades together using good posture.

stretching, performed by the patient in a corner or door jamb, and posterior shoulder stretching using the crossed body adduction technique. Each stretch should be held for 30 seconds and repeated 5 times, with a 10-second rest between each stretch. Cane stretching in forward elevation and external rotation may also be used in a similar fashion (see Figure A4).

Strengthening (Figures A8-A15): Strengthening exercises should focus on the rotator cuff and scapula stabilizing muscles. Rotator cuff strengthening should involve the following exercises with the TheraBand: internal rotation with the arm adducted to side, external rotation with the arm adducted to side, and scaption if there is no pain associated with the exercise. Scapula stabilizer strengthening should include chair press, push-up plus (prone using body weight or supine with hand weight), and upright rows using an elastic band. Combination strengthening while standing using elastic bands should include forward elevation and extension. Each exercise should be performed as 3 sets of 10 repetitions, with increases in elastic resistance as strength improves.

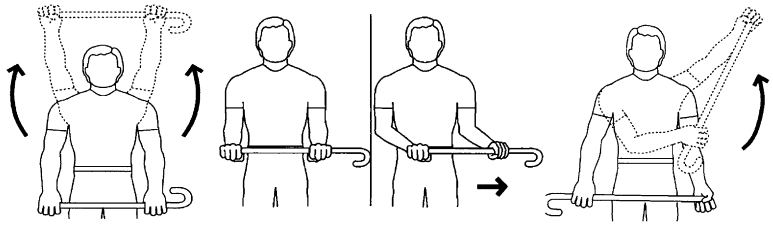

Figure A4 Active assisted range of motion using a cane: Lying supine, hold the cane with both hands. Elevate the arms using the healthy arm to guide the injured arm. Increase the use of the injured arm as directed by comfort. These can be done upright when comfortable. Images demonstrate forward elevation, external rotation, and abduction. Can do standing if comfortable.

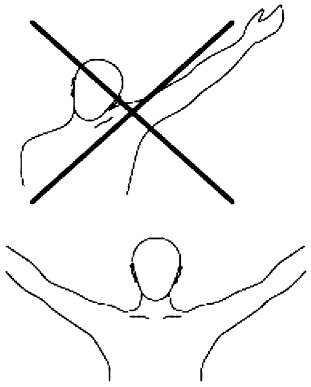

Figure A5 Active range of motion. In front of a mirror, practice raising your arm in front of your body without shrugging your shoulder.

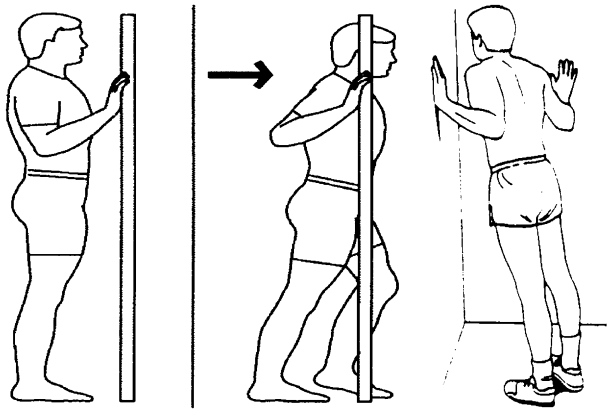

Figure A6 Anterior shoulder stretch: Place hands at shoulder level on each side of a door or in a corner of a room. Lean forward into the door or corner and hold.

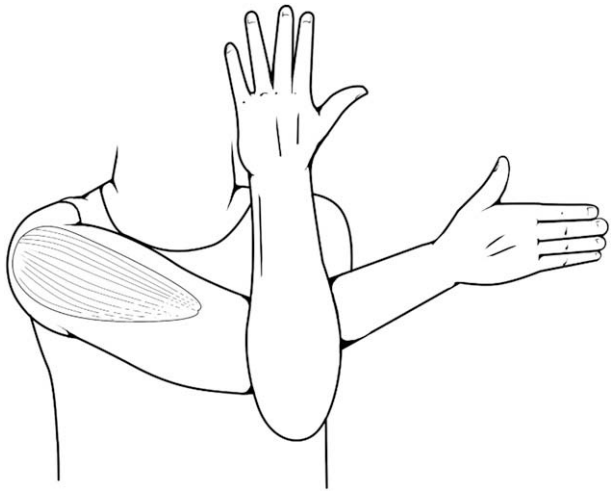

Figure A7 Posterior shoulder stretch: Bring the involved arm across in front of the body as shown. Hold the elbow with the other arm. Gently flex the bent arm, which will pull the other arm across the chest until a stretch is felt in the back of the shoulder.

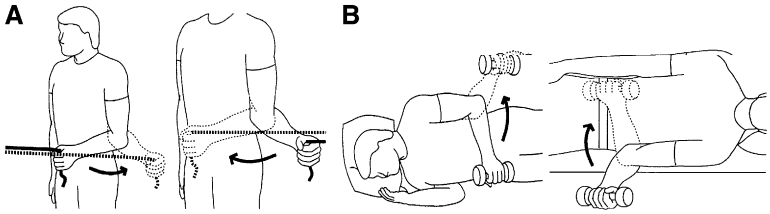

Figure A8 **A (Left),** External rotation: Secure the elastic band at waist level. Hold the elbow at 90°, arm at the side. Pull the hand away from the body as shown. **(Right)** Internal rotation: Secure the elastic band at waist level. Hold the elbow at 90°, arm at the side. Pull the hand across the body as shown. ***OR*** **B (Left),** External rotation: Lie on side, involved side up. Arm at side, elbow bent, with or without weight. Move the hand up as shown. **(Right)** Internal rotation: Lie on involved side, elbow bent at 90°, arm at side. With or without weight, pull hand inward across the body, as shown.

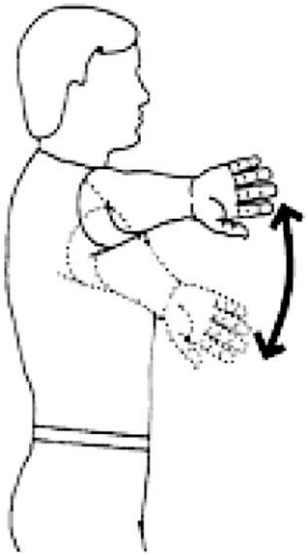

Figure A9 Scaption: Hold the arm 30° forward, thumb up or down, raise the arm. May add resistance. This exercise should be done only if there is no pain.

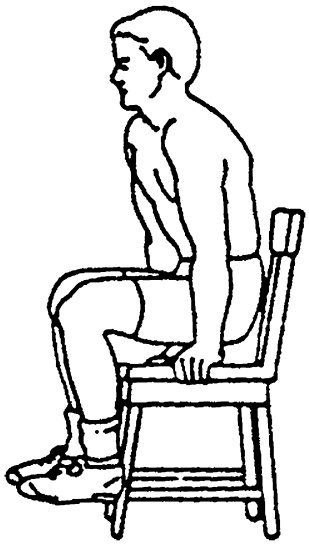

Figure A10 Chair press: While seated, press up on the chair, lifting the body off the chair. Try to keep the spine straight.

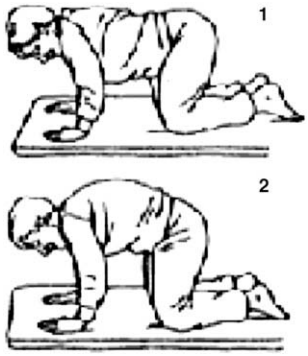

Figure A11 Push-up plus: Do a push-up (either on your hands or forearms) and then really push to bring your spine to the ceiling.

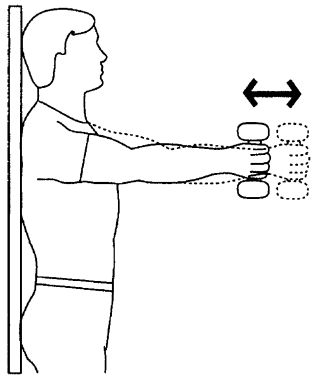

Figure A12 Press-up: Lie on back, elbow locked straight, weights in hands. Move your arm up toward the ceiling as far as possible.

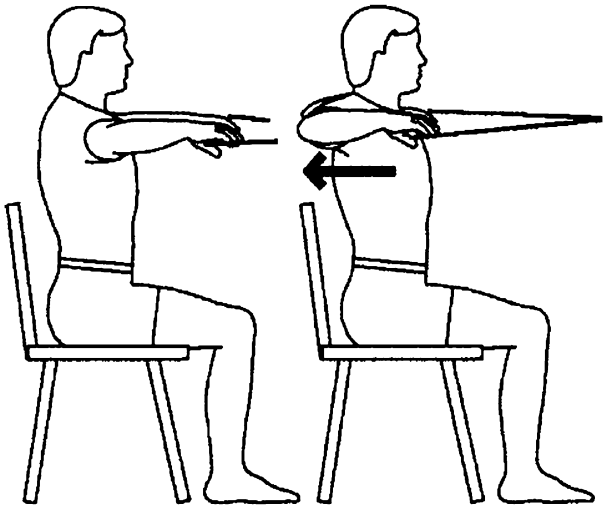

Figure A13 Rows: Seated or standing, bend your elbows and pull the elastic cord back. Try to pinch your shoulder blades behind you.

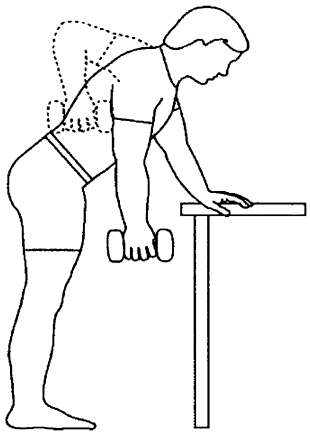

Figure A14 Upright row: Do one arm at a time. While standing, lean over a table and bend at the waist. Pull the hand weight back, pulling shoulder blade back.

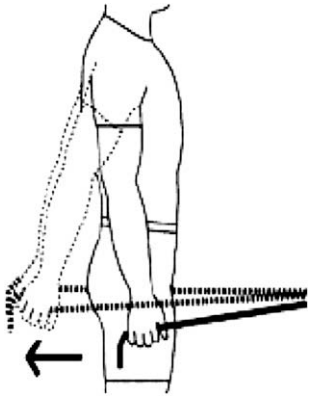

Figure A15 Low trapezius: Stand upright. Grasp elastic bands. Keep your elbows straight and pull. Try to reach behind you.