Research Report

Comparison of High-Grade and Low-Grade Mobilization Techniques in the Management of Adhesive Capsulitis of the Shoulder: Randomized Controlled Trial

Background and Purpose. In many physical therapy programs for subjects with adhesive capsulitis of the shoulder, mobilization techniques are an important part of the intervention. The purpose of this study was to compare the effectiveness of high-grade mobilization techniques (HGMT) with that of low-grade mobilization techniques (LGMT) in subjects with adhesive capsulitis of the shoulder. **Subjects.** One hundred subjects with unilateral adhesive capsulitis lasting 3 months or more and a ≥50% decrease in passive joint mobility relative to the nonaffected side were enrolled in this study. **Methods.** Subjects randomly assigned to the HGMT group were treated with intensive passive mobilization techniques in end-range positions of the glenohumeral joint, and subjects in the LGMT group were treated with passive mobilization techniques within the pain-free zone. The duration of treatment was a maximum of 12 weeks (24 sessions) in both groups. Subjects were assessed at baseline and at 3, 6, and 12 months by a masked assessor. Primary outcome measures included active and passive range of motion and shoulder disability (Shoulder Rating Questionnaire [SRQ] and Shoulder Disability Questionnaire [SDQ]). An analysis of covariance with adjustments for baseline values and a general linear mixed-effect model for repeated measurements were used to compare the change scores for the 2 treatment groups at the various time points and over the total period of 1 year, respectively. **Results.** Overall, subjects in both groups improved over 12 months. Statistically significant greater change scores were found in the HGMT group for passive abduction (at the time points 3 and 12 months), and for active and passive external rotation (at 12 months). A statistically significant difference in trend between both groups over the total follow-up period of 12 months was found for passive external rotation, SRQ, and SDQ with greater change scores in the HGMT group. **Discussion and Conclusion.** In subjects with adhesive capsulitis of the shoulder, HGMTs appear to be more effective in improving glenohumeral joint mobility and reducing disability than LGMTs, with the overall differences between the 2 interventions being small. [Vermeulen HM, Rozing PM, Obermann WR, et al. Comparison of high-grade and low-grade mobilization techniques in the management of adhesive capsulitis of the shoulder: randomized controlled trial. *Phys Ther.* 2006;86:355–368.]

Key Words: *Adhesive capsulitis, Physical therapy techniques, Shoulder, Treatment outcome.*

Henricus M Vermeulen, Piet M Rozing, Wim R Obermann, Saskia le Cessie, Thea PM Vliet Vlieland

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Adhesive capsulitis of the shoulder is characterized by insidious and progressive pain and loss of active and passive mobility of the glenohumeral joint. The annual incidences of adhesive capsulitis are 3% to 5% in the general population and up to 20% in people with diabetes.[1,2] The etiology and pathology of this syndrome remain enigmatic.[3–6]

In adhesive capsulitis, capsular extensibility is decreased, the axillary recess becomes adherent, and the flexibility of the biceps tendon in its sheath is reduced.[7] As a result, the external rotation of the humeral head to pass under the acromion during abduction is severely restricted. Restoring this mechanism is the primary goal of various treatment strategies for adhesive capsulitis.

A considerable proportion of patients with adhesive capsulitis are treated with nonsteroidal anti-inflammatory drugs, intra-articular corticosteroid injections, and physical therapy. In persistent cases, more aggressive interventions, such as hydrodilatation, arthroscopic release, or manipulation under anesthesia, have been used.[8]

With respect to physical therapy, a variety of interventions are used; these include heat or ice applications, ultrasound, interferential therapy, transcutaneous electrical nerve stimulation, active and passive range-of-motion (ROM) exercises, proprioceptive neuromuscular facilitation (PNF) techniques, and mobilization techniques.[9–12] From a recent systematic review of the effectiveness of physical therapy interventions for shoulder pain, Green et al[13] concluded that there is no evidence that physical therapy without concurrent interventions, such as corticosteroid injections, is of benefit for adhesive capsulitis. The authors of this review stressed the need for trials of physical therapy interventions for specific clinical conditions associated with shoulder pain.

In many physical therapy programs, mobilization techniques are an important part of the intervention. Mobilization techniques can be performed as physiologic movements or accessory movements (Appendix 1). Physiologic movements at the glenohumeral joint are movements of the humerus in the cardinal planes (eg, flexion, extension, abduction, adduction, external rotation, and internal rotation). Accessory movements are movements that are passively induced by a therapist and consist of rolling, gliding (or sliding), spinning, and distraction within the joint.[14,15] The intensity of the mobilization techniques with rhythmic oscillatory movements usually is categorized according to the 5-grade classification system of Maitland (Appendix 1).[16,17]

From 1984 to 2004, 5 controlled studies[9,18–21] describing the effectiveness of mobilization techniques in subjects

HM Vermeulen, PhD, is Physical Therapist and Manual Therapist, Department of Physical Therapy, H0-Q, Leiden University Medical Center, PO Box 9600, 2300 RC Leiden, the Netherlands (h.m.vermeulen@lumc.nl). Address all correspondence to Dr Vermeulen.

PM Rozing, MD, PhD, is Professor of Orthopaedics, Department of Orthopaedics, Leiden University Medical Center.

WR Obermann, MD, PhD, is Radiologist, Department of Radiology, Leiden University Medical Center.

S le Cessie, PhD, is Statistician, Department of Medical Statistics, Leiden University Medical Center.

TPM Vliet Vlieland, MD, PhD, is Epidemiologist, Departments of Physical Therapy and Rheumatology, Leiden University Medical Center.

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The local Medical Ethics Committee approved the study protocol.

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with adhesive capsulitis of the shoulder were published. In one randomized controlled trial comparing passive mobilization techniques (3 times per week for 6 weeks, intensity unknown) with intra-articular steroid injections, ice therapy followed by PNF, or no therapy,[9] few long-term (6 months) advantages of any of the treatment regimens over no treatment were seen. In 1 of 2 studies comparing the effects of passive mobilization techniques (2 or 3 times per week for 4 weeks, up to grade IV accessory motions according to the Maitland classification system) in addition to active exercises with active exercises alone, a positive effect regarding passive abduction was seen after 4 weeks in the mobilization group,[18] whereas in the other study, no additional effect of passive mobilization techniques (once per week for 5–8 weeks, grades III and IV according to the Maitland classification system, without further specification of techniques) could be demonstrated.[20]

In another study comparing local steroid injections, mobilization (for 4–6 weeks, without further specification), and a combination of both, local steroid injections proved to be as effective as mobilization alone or in combination after 6 weeks and 6 months.[19] In a study with a quasi-experimental design, subjects were treated with intensive physical rehabilitation (a standardized treatment protocol executed by a physical therapist of active exercises up to and beyond the pain threshold, passive stretching and manipulation of the glenohumeral joint, and home exercises aimed at stretching and maximal reaching) or supervised neglect (subjects were provided an explanation of the natural course of the disease, were instructed not to exercise in excess of their pain threshold, and were instructed to do pendulum exercises and active exercises within this painless range and to resume all activities that were tolerated). Whenever necessary, anti-inflammatory medication (nonsteroidal anti-inflammatory drugs) or analgesics were prescribed to patients in both groups. There was no information provided about the duration or intensity of the mobilization techniques).[21] Supervised neglect proved to be superior to passive mobilization and stretching with regard to the functional status and the speed of recovery. In addition to controlled clinical trials, one uncontrolled study described a positive effect of grade III and IV mobilization techniques (2 times per week for 12 weeks) after 3 months in 7 subjects with adhesive capsulitis.[22]

The interpretation of the results of all of these studies is hampered by methodologic flaws, such as small numbers of subjects,[9,18,22] high dropout rates,[20] and a short duration of follow-up.[18,20] Moreover, the intensity and duration of the mobilization techniques may have varied among the aforementioned studies or may have been insufficiently described.[9,19–21] Therefore, the effectiveness of mobilization techniques of various intensities in improving shoulder ROM and function is still unknown. For this reason, we conducted a randomized controlled trial focusing on the effectiveness of mobilization techniques with different intensities (high-grade mobilization techniques [HGMT] and low-grade mobilization techniques [LGMT]) in a group of subjects with adhesive capsulitis of the shoulder.

Method

Subject Recruitment

The trial was conducted at the outpatient clinic of the Department of Physical Therapy at Leiden University Medical Center. Subjects were recruited by orthopedic surgeons from 6 hospitals in the region of Leiden between August 1999 and May 2002. All subjects gave written informed consent.

Subject Selection

Subjects were eligible if they fulfilled the following inclusion criteria: unilateral adhesive capsulitis defined as ≥50% loss of passive movement of the shoulder joint relative to the nonaffected side, in 1 or more of 3 movement directions (ie, abduction in the frontal plane, forward flexion, or external rotation in 0° of abduction)[5,10,21,23,24]; duration of complaints of ≥3 months; and ability to complete questionnaires in Dutch. Exclusion criteria were: previous manipulation under anesthesia of the affected shoulder; other conditions involving the shoulder (eg, rheumatoid arthritis, osteoarthritis, damage of the glenohumeral cartilage, Hill-Sachs lesion, osteoporosis, or malignancies in the shoulder region); neurologic deficits affecting shoulder function in normal daily activities; pain or disorders of the cervical spine, elbow, wrist, or hand; and injection with corticosteroids in the affected shoulder in the preceding 4 weeks. Subjects with diabetes mellitus were accepted.

Subjects

A total of 163 subjects were initially recruited between August 1999 and March 2002. Sixty-three subjects were excluded; 47 of them did not fulfill the inclusion criteria, and 16 declined to participate for personal reasons. Thus, 100 subjects entered the study and were randomly assigned to either the HGMT group (n=49) or the LGMT group (n=51) (Figure). In both groups, 2 subjects withdrew from the trial in the first 3 months and were lost to follow-up. One violation of the protocol occurred in the HGMT group after 3 weeks, as the subject did not want to be treated in either of the treatment groups anymore. She was further treated for 3 months by a physical therapist who was not involved in this study, but she did return for the follow-up visits.

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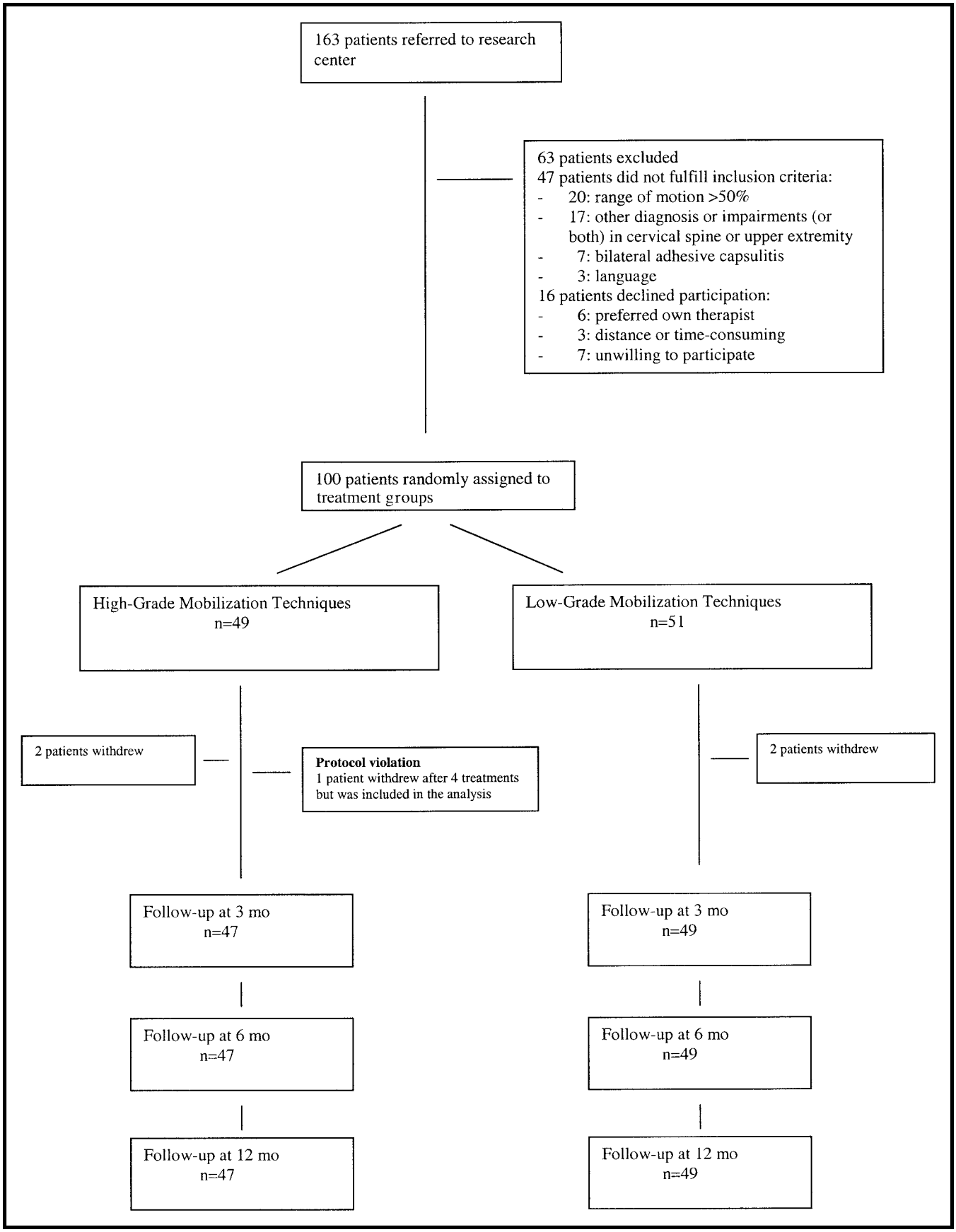

Figure.
Flow chart for adhesive capsulitis study.

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Table 1.
Baseline Characteristics of 100 Participants With Unilateral Adhesive Capsulitis in a Randomized Controlled Trial Comparing 2 Different Mobilization Techniques[a]

Characteristic	High-Grade Mobilization Technique Group (n=49)	Low-Grade Mobilization Technique Group (n=51)	P[b]
Age, y, $\bar{X}$ (SD)	51.6 (7.6)	51.7 (8.6)	.97
Women/men (n)	32/17	34/17	.89
Dominant shoulder involved, no. (%) of subjects	23 (47)	31 (61)	.16
Duration of complaints, mo (range)	8 (5–14.5)	8 (6–14)	.45
Prior treatment of involved shoulder			
Physical therapy			
No. (%) of subjects	39 (79)	42 (82)	.73
No. (range) of treatments	19 (10–27)	19 (12–36)	.88
Injection			
No. (%) of subjects	32 (65)	29 (57)	.65
No. (range) of injections	2 (1–3)	2 (1–4)	.98
Surgery, no. (%) of subjects	3 (6)	3 (6)	.94
Current pain medication, no. (%) of subjects	19 (39)	20 (39)	.97
Same complaints in opposite shoulder before, no. (%) of subjects	9 (18)	8 (16)	.72
Diabetes (insulin dependent), no. of subjects	8 (6)	8 (6)	.93
Paid employment, no. (%) of subjects	34 (69)	34 (66)	.77
Participating in sports, no. (%) of subjects	31 (63)	31 (61)	.89
Leisure activities, no. (%) of subjects	34 (69)	37 (72)	.33

[a] Measures with a non-Gaussian distribution are expressed as median and interquartile range (25th–75th).
[b] Differences between groups were analyzed with a Student unpaired *t* test, a Mann-Whitney *U* test, or a chi-square test as appropriate. The level of significance was set at $P<.05$.

The baseline sociodemographic and clinical characteristics were similar in the 2 groups (Tabs. 1 and 2). Eighty percent of the subjects in both groups had been treated previously by a physical therapist, and 60% of the subjects had received one or more steroid injections in the affected shoulder. Nineteen and 20 subjects in the HGMT and LGMT groups, respectively, currently took pain medication for the shoulder complaints. As determined by the radiologic assessment at baseline, the mean joint capacities in the HGMT and LGMT groups were 10.2 cm^3 (SD=4.3) and 10.8 cm^3 (SD=4.3), respectively ($P=.54$). In 6 subjects, 3 in each group, the arthrography failed, and no joint capacity could be measured.

Randomization Procedure

Randomization was done by a random-number generator with permuted blocks of 4 and stratification for the presence of diabetes mellitus and for joint capacity as measured by arthrography ($\leq$15 or $>$15 cm^3). The latter stratification was done because joint capacity may vary in people with adhesive capsulitis,[5,22] and its potential influence on the recovery process remains unknown. After the baseline assessments were carried out, an administrative assistant assigned the subjects to the intervention groups according to the randomization scheme.

Interventions

All treatments were done by 2 groups of physical therapists with at least 3 years of clinical experience with the application of mobilization techniques. The physical therapists who performed the HGMT were certified manual therapists; the other physical therapists had a general physical therapy background. Before the study, all physical therapists involved attended a 3-hour training program in order to familiarize themselves with the mobilization techniques they had to perform. Therapists did not shift between the HGMT and the LGMT groups during the total duration of the trial to prevent interference from 2 treatment strategies. In both groups, subjects were treated twice per week for 30 minutes for a maximum of 12 weeks and were encouraged to attend all treatment sessions. If the therapist noticed a normal ROM relative to the unaffected side, then reducing the frequency to once per week and stopping the treatment were permitted, provided that each subject had had a minimal duration of exposure to the therapy of at least 6 weeks. In both groups, subjects did not receive a home exercise program but were advised to use the affected shoulder in daily activities whenever possible.

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Table 2.
Results for Shoulder Function, Activities Involving the Shoulder, and Quality of Life at Baseline and at 3, 6, and 12 Months of Follow-up in 100 Subjects With Adhesive Capsulitis Treated With High-Grade Mobilization Techniques (HGMT) or Low-Grade Mobilization Techniques (LGMT)

Parameter	Mobilization Technique	Baseline Median (Interquartile Range)[a]	Mean Change (95% Confidence Interval) at: 3 mo	6 mo	12 mo	*P* for Difference in Trend Over 12 mo (General Linear Mixed-Effect Model)
Active abduction, degrees	HGMT	75.0 (60.0 to 90.0)	46.3 (37.0 to 55.6)	55.8 (45.1 to 66.4)	72.9 (63.8 to 81.9)	
	LGMT	75.0 (67.5 to 85.0)	36.3 (28.2 to 44.4)	46.9 (37.9 to 55.8)	60.3 (51.1 to 69.4)	.059
Active forward flexion, degrees	HGMT	95.0 (85.0 to 110.0)	27.6 (21.9 to 33.3)	34.2 (27.5 to 40.9)	47.0 (40.0 to 54.1)	
	LGMT	90.0 (80.0 to 107.5)	24.9 (20.2 to 29.6)	33.6 (28.9 to 38.4)	42.9 (37.3 to 48.5)	.38
Active external rotation, degrees	HGMT	20.0 (10.0 to 25.0)	11.6 (8.4 to 14.9)	15.9 (12.2 to 19.5)	20.8 (17.4 to 24.3)[b]	
	LGMT	20.0 (7.5 to 30.0)	9.3 (5.2 to 13.4)	13.2 (9.5 to 16.9)	15.9 (11.4 to 20.5)	.051
Passive abduction, degrees	HGMT	85.0 (70.0 to 95.0)	47.9 (38.8 to 57.0)[b]	57.1 (47.2 to 67.0)	72.4 (64.0 to 80.9)[b]	
	LGMT	85.0 (80.0 to 95.0)	34.8 (27.3 to 42.2)	46.1 (37.7 to 54.6)	59.9 (51.7 to 68.1)	.052
Passive forward flexion in degrees	HGMT	105.0 (95.0 to 115.0)	27.8 (22.8 to 32.8)	32.9 (26.7 to 39.2)	44.6 (38.0 to 51.2)	
	LGMT	95.0 (90.0 to 112.5)	23.8 (19.4 to 28.2)	31.7 (26.8 to 36.5)	41.4 (36.0 to 46.8)	.54
Passive external rotation, degrees	HGMT	20.0 (10.0 to 30.0)	13.1 (9.7 to 16.5)	16.8 (13.0 to 20.7)	21.9 (17.8 to 26.0)[b]	
	LGMT	20.0 (12.5 to 35.0)	11.7 (8.0 to 15.4)	12.7 (9.2 to 16.2)	15.4 (10.5 to 20.3)	<.01
Pain at rest, VAS	HGMT	28.0 (15.0 to 65.0)	−15.0 (−5.9 to −24.0)	−22.3 (−32.1 to −12.4)	−23.9 (−31.7 to −16.0)	
	LGMT	36.0 (20.0 to 64.5)	−22.1 (−15.6 to −28.7)	−24.3 (−31.3 to −17.4)	−23.0 (−30.8 to −15.2)	.66
Pain during movement, VAS	HGMT	59.0 (46.0 to 78.0)	−26.9 (−19.0 to −34.7)	−31.4 (−39.5 to −23.2)	−39.2 (−47.2 to −31.2)	
	LGMT	62.0 (37.5 to 77.0)	−24.3 (−16.1 to −32.5)	−31.9 (−39.2 to −24.5)	−32.6 (−41.4 to −23.8)	.34
Pain at night, VAS	HGMT	72.0 (47.0 to 84.0)	−31.3 (−20.3 to −42.4)	−38.8 (−50.8 to −26.9)	−43.7 (−53.6 to −33.8)	
	LGMT	63.0 (31.0 to 78.5)	−27.5 (−19.0 to −35.9)	−31.7 (−40.1 to −23.4)	−35.9 (−44.4 to −27.4)	.18
Shoulder Rating Questionnaire, total score	HGMT	37.5 (28.7 to 47.0)	25.8 (20.8 to 30.8)	32.3 (26.8 to 37.9)	38.3 (32.8 to 43.8)	
	LGMT	39.5 (31.0 to 49.6)	23.4 (19.1 to 27.6)	27.8 (23.4 to 32.2)	31.7 (26.8 to 36.7)	.049
Shoulder Disability Questionnaire, total score	HGMT	81.2 (75.0 to 87.5)	−29.9 (−22.2 to −37.6)	−38.9 (−49.1 to −30.7)	−50.0 (−58.7 to −41.2)	
	LGMT	81.2 (71.9 to 93.7)	−24.7 (−17.8 to −31.6)	−33.2 (−41.0 to −25.5)	−38.8 (−46.5 to −31.0)	.033
SF-36[c] physical component score	HGMT	43.8 (31.9 to 54.2)	14.2 (9.6 to 18.8)	19.2 (13.8 to 24.6)	23.2 (16.9 to 29.5)	
	LGMT	45.1 (36.3 to 57.5)	13.6 (8.6 to 18.6)	17.1 (12.1 to 22.1)	22.8 (17.2 to 28.3)	.79
SF-36 mental component score	HGMT	73.4 (51.9 to 87.0)	8.6 (3.7 to 13.5)	8.2 (2.4 to 14.1)	7.7 (1.8 to 13.5)	
	LGMT	73.2 (51.9 to 83.5)	4.5 (−2.1 to 11.1)[d]	7.9 (1.8 to 14.0)	10.2 (3.9 to 16.6)	.34

[a] No significant differences between HGMT and LGMT groups at baseline.
[b] Significant difference ($P<.05$) between 2 groups at follow-up, as determined by analysis of covariance with correction for baseline values.
[c] SF-36=36-Item Short-Form Health Survey.
[d] No significant change within the LGMT group at 3 months compared with the baseline value ($P=.15$).

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Description of the Mobilization Techniques

In both groups, every session started with a 5-minute assessment of the ROM by performing all 3 physiologic movements of the glenohumeral joint passively with the subject in the supine position (Appendix 2). At each position of the shoulder, the end-feel of the movement was assessed in order to apply the mobilization techniques into the stiffness zone (HGMT group) or within the pain-free zone (LGMT group).

The treatment started with inferior glides aimed at improvement of the extensibility of the axillary recess. Both hands were held close to the humeral head to work with a short-lever arm. Oscillatory movements in the caudal, lateral, and anterior directions were used. To influence the posterior part of the joint capsule, the hand was placed on the anterior part of the shoulder, and the applied force was in the posterior and lateral directions. To treat the anterior part of the capsule, an anterior and medial glide was applied with one hand pushing on the posterior part of the humeral head. Distraction of the humeral head with respect to the glenoid was performed by pulling the humeral head in the superior, lateral, and anterior directions with a firm grip of both hands close to the humeral head and pushing the scapula on the table. If the fixation of the scapula proved to be difficult, a reversed distraction technique was applied,[10,22] with the subject lying on the unaffected side. The therapist supported the affected arm and moved the shoulder into the end-range of elevation. The heel of the other hand pushed against the lateral border of the scapula in medial rotation to produce distraction within the glenohumeral joint.

If the glenohumeral joint ROM increased during treatment, then mobilization techniques were performed at greater elevation and abduction angles. In these new positions, the changed position of the humeral head and glenoid required an individual adjustment of the direction of the accessory movements in accordance with the concave-convex rules stated by Kaltenborn.[14,17] Modification of the mobilization techniques consisted of more abduction or adduction, more flexion or extension, more internal or external rotation, more distraction, or a combination of adjustments.

HGMT intervention. For the HGMT group, the abovementioned mobilization techniques were applied with intensities according to Maitland grades III and IV. The duration of prolonged stress on the shoulder capsule in the end-range position varied according to the subject's tolerance ("treating the stiffness"). Subjects were instructed to inform the therapist about the degree and nature of pain during and after treatment. If pain influenced the execution of the mobilization techniques in a negative way (by increasing the reflex muscle activity), then the therapist altered the direction or degree of mobilization as described earlier. If subjects experienced a dull ache, without increased reflex muscle activity, then the mobilization techniques were continued. Subjects were informed that this ache could last for a few hours after the treatment session. If the pain worsened or continued for more than 4 hours after treatment ("treatment soreness"),[14] then the intensity of the mobilization techniques was decreased in the next session.

LGMT intervention. In contrast to the protocol used for the HGMT group, the therapist explicitly informed the subjects that all techniques should be performed without causing pain in the shoulder. Mobilization techniques commenced in the basic starting positions with translation and distraction techniques performed with the joint near its neutral position (grade I). Reflex muscle activity was carefully monitored because it can be a first indication of joint pain. If joint mobility increased, then mobilization techniques were adjusted, and the amplitude of movements was increased without reaching the limits of ROM (grade II).

In the last 3 minutes of each treatment session, passive PNF patterns[25,26] within the pain-free zone in the supine position were applied. In addition, Codman pendular exercises[27] were performed for 2 minutes in a prone position to move the shoulder joint in more than one direction at a time and to obtain maximal relaxation of the shoulder muscles. All techniques used in connection with the LGMT intervention were aimed at the glenohumeral joint and did not specifically intend to move the scapulothoracic joint.

Cointerventions and Treatments After the Initial Intervention Period of 12 Weeks

Neither intra-articular injections with corticosteroids in the affected shoulder or any other joint nor any other concurrent interventions for adhesive capsulitis were allowed in the first 3 months of the trial, except for the use of pain medication—either self-medication or medication prescribed by a physician. Information on medication or any other treatment was obtained at each follow-up visit. After the intervention period of 12 weeks, all subjects were referred to the orthopedic surgeon for examination. Further treatment was left to the judgment of the orthopedic surgeon, in consultation with the subject. The therapists who treated the subjects in conjunction with the trial were not involved in the decision regarding further treatment. If continuation of physical therapy was decided, then the subject was referred to a therapist in a private practice. Only the number of these additional treatments was recorded.

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Table 3.
Psychometric Properties of the Outcome Measures

	Test-Retest Reliability	Responsiveness		
		SRM	ES	Area Under the ROC Curve
Shoulder range of motion	.94–.98[29]	0.38–0.88[31]	0.25–0.85[31]	
Shoulder Rating Questionnaire	.85[31]	1.17[31]	1.5[31]	0.85[33]
Shoulder Disability Questionnaire		0.91[31]	1.67[31]	0.77[33]
36-Item Short-Form Health Survey physical health component	>.80 (all dimensions)[2]	0.65[31] >0.9[36]	0.72[31] >0.9[36]	0.84–0.88[34]
Visual analog scale for shoulder pain	.93[35]	0.60–0.81[31] >1.0[36]	0.61–0.93[31] >1.0[36]	

SRM=standardized response mean, ES=effect size, ROC=receiver operating characteristic.

Examination Methods

All examinations were carried out by a masked assessor who is a trained physical therapist and manual therapist (HMV). Subjects were instructed not to reveal any details about the treatment or therapist to the assessor.

Demographic data, including age, sex, employment status, and sports and leisure activities, were recorded at baseline. A history was taken concerning the duration of complaints (months), previous treatments (injections, physical therapy), and current pain medications. Concomitant diseases and the use of medications were registered. Moreover, arthrography of the affected shoulder was performed to measure joint capacity (in cubic centimeters). With respect to measures of outcome, subjects were assessed at baseline and at 3, 6, and 12 months later.

Active ROM and passive ROM were measured with a conventional goniometer in accordance with the guidelines of the American Academy of Orthopaedic Surgeons[28] and included abduction in the frontal plane, forward flexion, and external rotation with the arm in 0 degrees of abduction. These goniometric measurements of the shoulder have been found to be highly reliable provided that they are executed by the same physical therapist[29] (Tab. 3). All measurements were rounded off to the nearest 5 degrees, as is common in research practice.[9,22]

Shoulder disability was measured by means of 2 instruments: the Shoulder Rating Questionnaire (SRQ) and the Shoulder Disability Questionnaire (SDQ). The SRQ is a self-administered questionnaire including global assessment, pain, daily activities, recreational and athletic activities, work, satisfaction, and areas for improvement.[30] The total score ranges from a minimum of 17 points (worst functional status) to a maximum of 100 points (best functional status). The SRQ has been translated into Dutch and validated for use in the Netherlands. The test-retest reliability (ICC) of scores for the Dutch SRQ was .85 in subjects with various shoulder disorders.[31] (Tab. 3) In addition, the Dutch language version of the SDQ was used.[32] It covers 16 items each with 3 answering options—"yes," "no," and "not applicable"—calculated into a summary score. The score ranges from a minimum of 0 points (no functional limitation) to a maximum of 100 points (affirmative answer to all applicable items). The validity of scores for the SDQ has been established along with those of other shoulder questionnaires; however, no data on reliability have been published.[33] Both the SRQ and the SDQ showed high values for measures of responsiveness in subjects who had various shoulder disorders and who received treatment[33,34] (Tab. 3).

Pain was measured with 3 separate visual analog scales (VAS; horizontal lines of 100 mm, with 0 indicating no pain on the left and 100 indicating very severe pain on the right). The 3 scales pertained to shoulder pain at rest, during movement, and during the night. A VAS has been found to be a reliable and sensitive tool for measuring pain, with test-retest reliability of >.90.[35] (type of statistic not reported) In previous studies of subjects treated for various shoulder disorders, the responsiveness of VAS for pain was moderate to good[31,36] (Tab. 3).

General health status was measured with the 36-Item Short-Form Health Survey (SF-36). The SF-36, the psychometric properties of which have been established for the Dutch language,[37] is a generic measure of quality of life comprising 8 subscales for physical functioning, social functioning, role limitations (physical problems), role limitations (emotional problems), mental health, vitality, pain, and general health perception. Each subscale generates a score from 0 to 100, with a higher score indicating better health. From these 8 health concepts, 2 summary scales, for physical health and mental health, can be computed.[38] The psychometric properties have

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been established in a Dutch-language version.[37] The test-retest reliability of the SF-36 is >.80 (type of statistic not reported) for all subscales.[39] In studies concerning various shoulder disorders, the physical health subscales of the SF-36 showed moderate to good responsiveness after treatment, whereas the sensitivity to clinical changes of the mental health subscales was small to moderate[31,36] (Tab. 3). The subjects' overall opinion about changes in shoulder disability was measured at 3, 6, and 12 months by asking them to rate their shoulder function in comparison with that at baseline on a 5-point Likert scale (1=much worse–5=much better).

Data Analysis

Sample size was based on the results of a pilot study by our own group with 29 subjects who had adhesive capsulitis treated with HGMT (published as a multiple-subject case report[22]). In that pilot study, active abduction improved from 81 to 127 degrees after 12 weeks of treatment, with the mean change being 46.5 degrees (SD=25.3). Assuming a similar improvement of 46.5 degrees in the HGMT group in the present study and an improvement of 60% of that change in the LGMT group, for an absolute improvement of 28 degrees, the difference in improvement between the 2 groups would be 18.6 degrees, a difference that appears to be clinically relevant. With a power of 90%, 39 subjects per group would be needed to detect this difference between the 2 groups, with $P<.05$ (2-tailed tests). Considering a drop-out rate of 15%, at least 90 subjects in total would be needed for the present study.

The Kolmogorov-Smirnov test was applied to assess the normality of the distribution of scores. To investigate the comparability of the 2 groups at baseline, an unpaired *t* test, a Mann-Whitney *U* test, or a chi-square test was performed, depending on the nature and distribution of the data. A *t* test or a Fisher exact test was used to analyze differences in the number of additional treatments needed after the initial treatment period.

The outcome analysis was based on an intention-to-treat principle, and all subjects were included in the analysis. For subjects lost to follow-up, all of the available data were used. For continuous outcome measures, change scores and their 95% confidence intervals were calculated by subtracting the follow-up results from the baseline results. An analysis of covariance, with adjustment for the baseline value of the variable examined, was used to compare the change scores between the 2 groups at the various time points separately. To compare the effectiveness over the total period of 1 year, a general linear mixed-effect model was used.[40] In this model, subject number was entered as a random factor, group (HGMT and LGMT) was entered as a fixed factor, and time (0, 3, 6, and 12 months) was entered as a linear covariate. In addition, an interaction term for group and time was included. To ascertain whether the trends over time were different for the 2 treatment groups, a test for an interaction between time and group was performed. All analyses were repeated with the presence of diabetes mellitus (yes or no) and joint capacity ($\leq$15 or >15 cm^3) as additional covariates. In addition, the analyses were repeated separately for subjects who received additional treatments for their shoulder complaints between 3 and 6 months or between 6 and 12 months and those who did not. Within each group, the magnitudes of change scores between 0 and 3 months, between 3 and 6 months, and between 6 and 12 months were computed and compared with a *t* test. Finally, the numbers of subjects experiencing subjective improvement in the 2 groups at 3, 6, and 12 months were compared with a chi-square test.

Results

Treatments and Concurrent Interventions

The mean numbers of treatment sessions were 18.6 (SD=4.9) in the HGMT group and 21.5 (SD=2.5) in the LGMT group ($P<.001$). At the consecutive follow-up visits, the numbers of subjects using medications for their shoulder complaints decreased from 19 subjects at baseline to 10 subjects at 3 months, 6 subjects at 6 months, and 7 subjects at 12 months in the HGMT group and from 20 subjects at baseline to 6 subjects at 3 months, 3 subjects at 6 months, and 7 subjects at 12 months in the LGMT group; these proportions were not significantly different between the 2 groups ($P=.23$, $P=.31$, and $P=.93$ at 3, 6, and 12 months, respectively).

Additional treatments between 3 and 6 months and between 6 and 12 months are shown in Table 4. Regarding the additional treatments of physical therapy in the periods between 3 and 6 months and between 6 and 12 months, no significant differences were found between the groups ($P=.85$ and $P=.74$, respectively).

Response to Treatment

In both groups, subjects improved significantly between baseline and all follow-up visits, regardless of the outcome measures used (Tab. 2). All change scores were normally distributed, substantiating the appropriateness of the analysis of covariance. With respect to active ROM, improvement of active external rotation was significantly greater in the HGMT group than in the LGMT group at 12 months. Over the total follow-up period of 12 months, there was a trend toward a significantly greater increase in active abduction and active external rotation in the HGMT group than in the LGMT group. With respect to passive ROM, the HGMT group had significantly greater improvement in passive abduction at the follow-ups at 3 and 12 months and passive external

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Table 4.
Number of Subjects Who Had Unilateral Adhesive Capsulitis and Who Received Additional Treatments After Initial Treatment for 3 Months With High-Grade Mobilization Techniques (HGMT) or Low-Grade Mobilization Techniques (LGMT)[a]

	3–6 mo			6–12 mo		
Treatment	**HGMT**	**LGMT**	***P***	**HGMT**	**LGMT**	***P***
Physical therapy						
No. of subjects	10	11	.85[b]	7	10	.74[b]
No. of treatments (SD)	11 (6)	11 (6)		15 (12)	14 (7)	
Injection	1	1	.99[c]	3	2	.67[c]
Manipulation under anesthesia	2	1	.61[c]	2	0	.24[c]
Chiropractic	0	1	.99[c]	0	2	.49[c]
Subacromial decompression	1	1	.99[c]	0	0	—[d]

[a] The decision whether to initiate further therapy for the affected shoulder was left to the referring specialist.
[b] As determined by a *t* test.
[c] As determined by a Fisher exact test.
[d] —No statistics.

Table 5.
Subjects' Opinions About Shoulder Function in Relation to Baseline Situation After Treatment for Unilateral Adhesive Capsulitis With High-Grade Mobilization Techniques (HGMT) or Low-Grade Mobilization Techniques (LGMT) at 3, 6, and 12 Months of Follow-up

	No. (%) of Subjects in the Indicated Group at:					
	3 mo		6 mo		12 mo	
Shoulder Function	**HGMT**	**LGMT**	**HGMT**	**LGMT**	**HGMT**	**LGMT**
(Much) worse or no change	6 (13)	6 (12)	6 (13)	5 (10)	4 (9)	9 (18)
Better or much better[a]	40 (87)	43 (88)	40 (87)	43 (90)	43 (91)	40 (82)

[a] No significant differences between both groups at 3, 6, and 12 months (as determined by a chi-square test: $P=.38$, $P=.53$, and $P=.66$, respectively).

rotation at the 12 months' follow-up and over the total period of follow-up than did the LGMT group.

The reduction in shoulder disability as measured with the SRQ and the SDQ was significantly greater in the HGMT group than in the LGMT group over the total period of 12 months. It should be noted that the increase in negative values for the SDQ and the increase in positive values for the SRQ both represent improvements. Regarding pain and general physical and mental health, no differences between the 2 groups were seen.

Additional analyses with adjustment for the presence of diabetes mellitus and for joint capacity did not change any of the above-mentioned results (data not shown). In addition, the analyses were repeated for subjects who received additional treatments for their shoulder complaints between 3 and 6 months or between 6 and 12 months and those who did not. In general, the same results were obtained, with improvements in the subjects who received additional treatments being smaller than those in the subjects in whom the treatments were stopped at 12 weeks (data not shown).

Within both groups, the change scores between baseline and 3 months were significantly higher than those between 3 and 6 months ($P<.05$ for all measures except the SF-36 mental component), whereas the change scores at 6 months were significantly higher than the change scores at 12 months ($P<.05$ for all measures except VAS at rest and the SF-36 mental component). The numbers of subjects reporting improvement compared with the baseline were similar in both groups, with 82% to 91% of the subjects rating their shoulder function as better or much better at the 3 follow-up assessments (Tab. 5).

Discussion

In this study comparing the effectiveness of 2 treatment strategies including mobilization techniques with different levels of intensity in subjects with unilateral adhesive capsulitis of the shoulder, it appeared that HGMTs were more effective than LGMTs in increasing mobility and functional ability. However, the differences were small overall, and with both treatment strategies, subjects showed clinically significant improvement.

Joint mobilization techniques are assumed to induce various beneficial effects. The neurophysiologic effect is based on the stimulation of peripheral mechanoreceptors and the inhibition of nociceptors.[17,41,42] The biomechanical effect manifests itself when forces are directed

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toward resistance but within the limits of a subject's tolerance. The mechanical changes may include breaking up of adhesions, realigning collagen, or increasing fiber glide[43] when specific movements stress the specific parts of the capsular tissue.[42] Furthermore, mobilization techniques are supposed to increase or maintain joint mobility by inducing rheologic changes in synovial fluid, enhanced exchange between synovial fluid and cartilage matrix, and increased synovial fluid turnover.[44]

In the Maitland classification system, the passive mobilization approach is not a recipe of specific techniques but rather a concept of management in which accessory and physiologic passive movements of the joint are applied at various grades of intensity depending on a subject's pain and joint stiffness. A vital component of the Maitland approach is that the treatment is based on constant assessment and reassessment, with subsequent individual modifications of treatment techniques.[45]

Randomized studies describing the effectiveness of mobilization techniques as a single intervention in subjects with adhesive capsulitis of the shoulder are scarce, and their results are conflicting. The comparison of our results with those of other randomized studies concerning the application of mobilization techniques in adhesive capsulitis is hampered by an insufficient description of the mobilization techniques in the majority of the available trials[9,19,21] and, except for ROM, the use of different outcome measures to evaluate treatment effects.[9,18–21] Maricar and Chok[20] reported the application of Maitland grade III and IV mobilizations, which appear to have intensities similar to those of the mobilization techniques used for the HGMT group in the present study. However, the results of their study were not expressed in terms of absolute data regarding the baseline situation and changes over time and therefore cannot be compared directly with our data. The intensities of the mobilization techniques applied in the study of Nicholson[18] appear to be comparable to those used for the HGMT group in our study; although the follow-up period was considerably shorter (4 weeks) than that in our study, significantly greater passive abduction in the mobilization group also was seen in that trial.

High-grade mobilization techniques in subjects with adhesive capsulitis were previously applied for 12 weeks in an uncontrolled study by our own group.[22] In that study, in 7 subjects with adhesive capsulitis, clinically significant improvements in joint ROM, pain, and activities of daily living were found at 3 months and at 9 months after the start of treatment. The changes after 3 months were in the same range as the improvements seen in the HGMT and LGMT groups in the present study.

Although more favorable effects of HGMT than of LGMT were seen in the present study, in the absence of a control group, we cannot comment on the effectiveness of LGMT in comparison with no treatment or placebo treatment. Therefore, it could be hypothesized that the improvements seen with LGMT could be attributed to the favorable natural course of the condition. Indeed, in the trial by Bulgen et al,[9] in which mobilization techniques were compared with no treatment, similar improvements were seen in both groups. The use of a placebo or sham treatment alongside the 2 treatment strategies of our trial could have provided more insight into the magnitude of the effect of treatment in comparison with no treatment; however, the aim of this study was to determine specifically the impact of the intensity of mobilization techniques.

In our study, a further improvement after the initial treatment period of 12 weeks was seen in both groups, in which about one quarter of the subjects received additional treatments. However, the improvements were significantly greater in the first 3 months than in the period between 3 months and 6 months and the period between 6 months and 12 months, indicating that the largest gain in improvement was attained during the treatment itself. Because the improvements attained between 3 and 12 months in the subjects receiving additional treatments after 3 months were similar to or smaller than those in the subjects for whom the treatments were stopped, it is unlikely that the improvements after 3 months could be attributed to additional treatments after 3 months. The ongoing progression of shoulder function after 3 months probably can be explained by the initial improvement, enabling subjects to use their shoulders more and more in daily activities, leading to a further increase in joint mobility and function.

In our study, HGMT was superior to LGMT for all outcome measures; however, only a minority of comparisons reached statistical significance. This consistent observation may indicate that the numbers of subjects included in the study were relatively low, so that this trial could reveal only large differences between the 2 groups. If more subjects had been included, it is conceivable that statistical significance could have been achieved for several outcome measures. However, in that scenario, the absolute differences between the 2 treatment strategies should have remained in the same range, and their clinical relevance still could be questioned. With the design of this study and its power calculation, we assumed that differences in improvement in abduction of 15% to 20% would be clinically significant; however, this magnitude of the treatment effect was not achieved in the present study. We found that the absolute clinical improvement in the LGMT group was considerable.

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Therefore, for subjects who are anxious about experiencing pain, LGMT could be the preferred treatment mode.

The decision as to whether or not to start treatment of adhesive capsulitis at all may be dependent on the course and duration of the symptoms. Our selection criteria were based on the inclusion of patients with phase II adhesive capsulitis.[46] In these patients, severe limitation of the passive mobility of the glenohumeral joint is prominent, and shoulder pain is apparent mainly in the end-range of the ROM. The subjects had a relatively long duration of complaints (median=8 months), and all subjects had been referred to an orthopedic surgeon because previous treatment proved to be unsuccessful. It is therefore conceivable that our group comprised a selection of subjects with a relatively unfavorable course. The results of this study, therefore, cannot be generalized to all patients with various stages of adhesive capsulitis of the shoulder. Some authors[5,47] differentiate between primary or idiopathic adhesive capsulitis (without intrinsic shoulder disorders) and secondary adhesive capsulitis (attributable to diabetes, hyperthyroidism, cardiac problems, prolonged immobilization, or trauma). In general, the outcome of treatment in subjects with secondary adhesive capsulitis is regarded as less successful. It is probably for this reason that in many studies, subjects with secondary adhesive capsulitis were excluded.[12,20,48,49] In our study, 16 subjects with diabetes (insulin and non–insulin dependent) were assigned equally to both treatment groups. In contrast to other investigators,[50] we found no evidence that these subjects with diabetes showed poorer results than subjects without diabetes.

Conclusion

In summary, HGMT proved to be more effective than LGMT in the management of adhesive capsulitis of the shoulder; however, subjects improved significantly with both treatment strategies, and the differences were small. Future studies, we believe, should investigate whether HGMTs applied in earlier stages of adhesive capsulitis are as effective as in the present study. Because the natural course of the disease remains a matter of dispute, the inclusion of a treatment strategy comprising no treatment or sham treatment is advocated. In order to be able to detect small yet clinically significant differences, it is important to include sufficient numbers of subjects.

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Appendix 1.

Movements and Intensity of Mobilization Techniques

Joint Motion According to Kaltenborn[14,17]:

- **Physiologic movements** at the glenohumeral joint are movements of the humerus in the cardinal planes (eg, flexion, extension, abduction, adduction, external rotation, and internal rotation).
- **Accessory movements** are movements that are passively induced by a therapist and consist of rolling, gliding (or sliding), spinning, and distraction within the joint:
  - **Rolling** is a movement in the joint in which 1 point on the joint surface has contact with only 1 point on the other joint surface.
  - **Gliding** is a movement in the joint in which 1 point on the joint surface has contact with many other points on the other joint surface.
  - **Roll and glide** must occur together for the joint to function properly.
  - **Spinning** is a pure rotary motion around 1 axis.
  - **Distraction** is a widening of the joint space with a separation of the 2 joint partners.

Intensity of Mobilization Techniques According to the Maitland 5-Grade Classification System[16]:

Grade I:	Small amplitude at the beginning of the range of motion (ROM)
Grade II:	Large amplitude not reaching the end of the ROM
Grade III:	Large amplitude reaching the limited ROM
Grade IV:	Small amplitude at the end of the limited ROM
Grade V:	Small amplitude and high velocity at the end of the limited ROM (manipulation or thrust) (not applied in this study)

Appendix 2.
Treatment Scheme for Application of High-Grade Mobilization Techniques (HGMT) and Low-Grade Mobilization Techniques (LGMT)

Mobilization Technique[a]	Subject Position	Duration (min)		Intensity	
		HGMT Group	LGMT Group	HGMT Group	LGMT Group
Assessment of limits of passive range of motion, capsular end feel, and accompanying pain					
Forward flexion/extension (P)	Supine				
Adduction/abduction (P)	Supine	5	5		
External/internal rotation (P)	Supine				
Mobilization techniques					
Inferior glide of (head of) humerus (A)	Supine	25	20	III or IV	I or II
Inferior glide of (head of) humerus in abduction/external rotation (A)	Supine				
Posterior glide of (head of) humerus (A)	Supine				
Anterior glide of (head of) humerus (A)	Supine/prone				
Lateral distraction of humerus (A)	Supine				
Distraction by means of scapular medial rotation (A)	Lying on unaffected side				
Passive PNF patterns (P)	Supine	3			
Codman pendular exercises (P)	Prone	2			

[a] P=physiological movement, A=accessory movement, PNF=proprioceptive neuromuscular facilitation.

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