Available online at www.medicinescience.org

ORIGINAL ARTICLE

Medicine Science International Medical Journal

Medicine Science 2026;35(2):572-81

The effect of proprioceptive neuromuscular facilitation and shoulder stabilization exercises on pain, quality of life and functionality in adhesive capsulitis

Safiye Gul Ozkan[1], Osman Coban[2]

[1]*Üsküdar University, Institute of Health Science, Department of Physical Therapy and Rehabilitation, İstanbul, Türkiye*
[2]*Üsküdar University, Faculty of Health Science, Department of Physical Therapy and Rehabilitation, İstanbul, Türkiye*

Received 12 October 2025; Accepted 12 November 2025
Available online 09 April 2026 with doi: 10.5455/medscience.2025.10.274

Abstract

Adhesive capsulitis (AC), often referred to as frozen shoulder, is a common musculoskeletal disorder characterized by pain, stiffness, and progressive limitation of shoulder mobility, which substantially impairs daily activities and quality of life. This study aimed to evaluate the effects of proprioceptive neuromuscular facilitation (PNF) and shoulder stabilization exercises on pain, range of motion (ROM), muscle strength, shoulder function, and quality of life in individuals with AC. Thirty-two participants diagnosed with AC were randomly assigned to two groups: the PNF group (n=16) (received conventional physiotherapy plus PNF exercises), and the Stabilization group (n=16), (received conventional physiotherapy plus stabilization exercises). Both groups underwent treatment once daily, five days a week for three weeks. Pain intensity (Visual Analog Scale – VAS), ROM (goniometry), muscle strength (manual muscle testing-MMT), shoulder functionality (Disabilities of the Arm, Shoulder and Hand – DASH), and quality of life (Short Form-12 – SF-12) were evaluated pre- and post-intervention. Statistically significant improvements were observed in the PNF group compared to the Stabilization group in shoulder flexion, abduction, adduction, and external rotation ROM, as well as in internal rotator muscle strength ($p<0.05$). However, no significant differences were found between the groups in pain intensity, DASH, or SF-12 scores ($p>0.05$). Both exercise approaches contributed positively to clinical outcomes in patients with AC. Nevertheless, PNF exercises appear to provide superior gains in ROM and muscle strength, indicating their potential as an effective adjunct to standard physiotherapy protocols.

Keywords: Adhesive capsulitis, pain, shoulder rehabilitation, proprioceptive neuromuscular facilitation, exercise therapy

Introduction

Adhesive capsulitis (AC), also known as frozen shoulder, is a common and painful shoulder condition characterized by a painful and gradual loss of active and passive shoulder motion, particularly affecting external rotation of the glenohumeral joint [1]. Affecting 2% to 5% of the population, frozen shoulder typically occurs in the 5th to 7th decades of life, more frequently in middle-aged women [2]. Although the exact cause of ACis unknown, it is a debilitating condition resulting from inflammation of the chronic capsular subsynovial layer, leading to fibrosis, contracture, thickening and loss of the normal axillary recess [3]. It can be divided into two categories: (1) primary or idiopathic AC, which may be associated with immunological, biochemical, or hormonal imbalances, with no history or examination findings explaining the onset of the disease, or (2) secondary AC, which is usually caused by trauma and subsequent immobilization, and is caused by various predisposing factors classified as systemic, intrinsic, or extrinsic in nature [4]. Patients with adherent capsulitis experience 3 phases, first a “freeze” phase in which pain and limited motion last 10–36 weeks; then a “frozen” stiffness phase lasting 4–12 months with reduced pain but lost range of motion; and finally a “thaw” phase lasting 5–26 months with less pain and limited motion returning [5]. Disability in the shoulder may last up to 2 years or longer during which time ROM is slowly regained. In some patients, full ROMis not regained even after four years [6].

CITATION
Ozkan SG, Coban O. The effect of proprioceptive neuromuscular facilitation and shoulder stabilization exercises on pain, quality of life and functionality in adhesive capsulitis. Med Science. 2026;35(2):572-81.

Corresponding Author: Osman Coban, Üsküdar University, Faculty of Health Science, Department of Physical Therapy and Rehabilitation, İstanbul, Türkiye
Email: oscoban28@gmail.com

Although the most effective treatment approach for AC remains unclear, numerous studies have evaluated the efficacy of various therapeutic modalities. Nonsurgical interventions commonly include corticosteroid injections, oral pharmacologic agents, electrotherapy modalities, extracorporeal shock wave therapy, therapeutic exercise programs, joint mobilization techniques, and muscle energy techniques (MET). Due to the lack of consensus regarding the optimal intervention strategy, a multimodal treatment approach is often employed in clinical practice [4]. While the majority of patients experience symptomatic relief with conservative management, early administration of corticosteroid injections has been associated with a shortened duration of symptoms. In cases where nonsurgical treatment fails to yield sufficient improvement, surgical options such as manipulation under anesthesia and arthroscopic capsular release may be considered [7].

PNF, originally developed by Knott and Kabat, is a widely utilized therapeutic approach in physiotherapy aimed at facilitating motor responses and enhancing neuromuscular control and function. It has been employed across a range of clinical populations, including individuals with sports-related injuries, orthopedic disorders, cardiopulmonary conditions, and neurological impairments. PNF techniques are designed to improve muscular strength, stability, endurance, mobility, and neuromuscular coordination [8]. Several studies have examined the efficacy of PNF in the management of AC, indicating potential benefits such as increased passive range of motion, pain reduction, and improved functional outcomes [9]. However, the current literature presents conflicting findings , and the optimal treatment strategy for AC remains a topic of ongoing debate [10].

Shoulder stability is defined as the proper and correct alignment of the humeral head within the glenoid fossa. Altered muscle activity; inappropriate or incorrect movement pattern of the scapular muscles is believed to be an important factor causing frozen shoulder by disrupting scapulothoracic kinematics [11]. Shoulder stabilization exercises are used to improve shoulder stabilization and eliminate movement dysfunctions due to abnormal scapular placement and abnormal dynamic control by maintaining effective length and tension of upper extremity movement through active movements of the muscles surrounding the scapula [12]. Stabilization exercises applied in the scapular plane do not apply excessive force to the shoulder joints. Therefore, such exercises can be used safely in patients with shoulder joint damage [13]. Scapular stabilization exercise training appears to provide positive results in many diseases that cause shoulder pain and functional impairment [14], but there is no study in the literature comparing it with PNF exercises in the treatment of frozen shoulder.

This study aimed to compare the therapeutic effects and potential advantages of proprioceptive neuromuscular facilitation and shoulder stabilization exercises in patients with AC, and to evaluate their short-term impact on shoulder movements and functional mobility.

Material and Methods

This controlled trial was conducted at a single center using a double-blind design, masking both outcome assessors and participants. The study was designed and reported in accordance with the CONSORT (Consolidated Standards of Reporting Trials) 2010 guidelines for randomized controlled trials [15]. The study received ethical approval from the Üsküdar University Non-Interventional Research Ethics Committee (Approval No: 61351342/December 2022-38; Approval date: December 28, 2022), and was registered at ClinicalTrials.gov (NCT05797311). All procedures were conducted in accordance with the 1983 revision of the Declaration of Helsinki, and written informed consent was obtained from all participants.

Participants

Between May 2023 and January 2024, 39 patients diagnosed with AC were recruited from the Department of Physical Therapy at Private Fizema Medical Center.. Eligibility criteria included: (1) age between 20 and 60 years; (2) unilateral Stage II AC verified by magnetic resonance imaging; (3) shoulder pain lasting at least three months; (4) a minimum score of 5 on the Visual Analog Scale (VAS); and (5) voluntary participation confirmed by written informed consent.

Participants were excluded if they had undergone any form of physical or manual therapy for the affected shoulder within the previous year; had a history of shoulder surgery, intra-articular injections, or joint manipulation; experienced pain or pathology in adjacent areas such as the cervical spine, elbow, wrist, or hand; had additional shoulder-related conditions including rotator cuff tear or tendinitis; or presented with chronic systemic diseases (neurological, rheumatologic, endocrine, cardiovascular, metabolic, or oncological). After screening, 32 eligible participants were randomly assigned to one of two treatment groups—the Proprioceptive Neuromusclular Exercise Group (PEG) or the Stabilization Exercise Group (SEG)—using a computer-generated randomization sequence to prevent selection bias. Allocation was conducted by an independent researcher not involved in the assessment or treatment process. The physiotherapist responsible for outcome evaluation was blinded to group allocation, while the therapist administering the exercises was unaware of the assessment results. Both groups received their respective interventions under identical environmental conditions to ensure methodological consistency and minimize bias.The sample size estimation was performed using G*Power 3.1 software [16]. A two-way repeated-measures ANOVA (Group × Time interaction) was selected as the statistical model. Drawing upon effect sizes reported in prior studies [17] and assuming an effect size of 0.90, a significance level of 0.05, a 95% confidence interval, and a statistical power of 0.80, the minimum sample requirement was determined as 32 participants (16 per group). Figure 1 provides a flow diagram of participant recruitment and follow-up. Each participant completed 15 physiotherapy sessions over a three-week period. Evaluations

 DOI: 10.5455/medscience.2025.10.274

were conducted at two stages: at baseline and after the three-week treatment period. The primary outcome was pain intensity, assessed by the VAS. Secondary measures included: muscle strength determined by Manual Muscle Testing (MMT); shoulder mobility measured with a goniometer; functional status assessed with the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire; and health-related quality of life evaluated using the 12-Item Short Form Health Survey (SF-12).

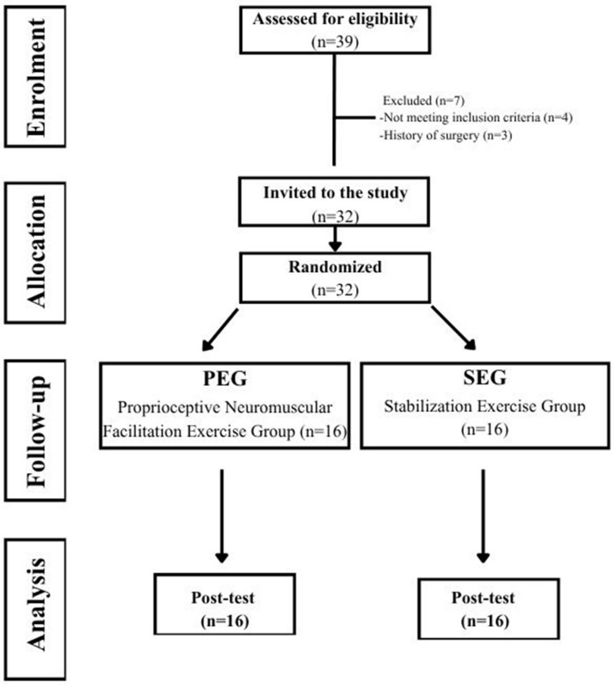

Figure 1. Flowchart of the study

Interventions

Both groups underwent a standardized 40-minute conventional rehabilitation program consisting of electrotherapy and structured stretching exercises. The stretching component included active-assisted and passive range of motion movements for the shoulder joint, such as wand exercises performed in a seated position (flexion, abduction, and external rotation) and Codman's pendulum exercises performed in a standing posture with the trunk slightly flexed and the arm relaxed.

For the PEG, the conventional program was followed by PNF applications derived from established clinical protocols. Participants performed the exercises in either supine or sitting positions, depending on comfort and target muscle groups. The PNF session consisted of a contract–relax method focusing on the subscapularis and internal rotators, involving a 7-second isometric contraction followed by 15 seconds of relaxation in external rotation, repeated five times [18]; and the D2 flexion pattern facilitated five times using manual resistance. Additionally, scapular PNF patterns were practiced in side-lying and seated positions utilizing rhythmic initiation and repeated contraction techniques to promote scapular mobility and neuromuscular coordination [19].

For the SEG, stabilization-based exercises were performed after the conventional program. These included scapular control and shoulder joint stabilization drills, emphasizing static holds and dynamic control. Exercises were executed mainly in sitting and standing positions. Each contraction was maintained for 10 seconds followed by a 3-second rest. One set included 10 repetitions, and three sets were completed in total [20].

All interventions were delivered five days per week for three consecutive weeks. Each session lasted approximately 60 minutes and was supervised by the same experienced physiotherapist to ensure uniformity and correct application of the exercise techniques.

Outcome Measures

Primary Outcome Measure

The primary outcome of this study was pain intensity, assessed using the VAS, a validated and widely adopted self-reported instrument for quantifying pain in various musculoskeletal conditions [21]. Participants were asked to rate their shoulder pain on a 10-centimeter horizontal line, where 0 cm represented "no pain" and 10 cm indicated "the worst imaginable pain".

Secondary Outcome Measures

Manual Muscle Testing (MMT)

Muscle strength was evaluated using MMT, a widely accepted clinical tool for assessing muscle performance. Each targeted muscle was examined through standardized techniques involving specific positioning, stabilization, and resistance application. Muscle strength was scored using the Medical Research Council (MRC) scale, which ranges from 0 (no contraction) to 5 (normal strength) [22].

Shoulder Range of Motion

Active shoulder joint mobility was measured using a universal goniometer, which remains the clinical gold standard for assessing ROM [23]. The device comprises two overlapping, adjustable arms, allowing precise angular measurements. Each ROM measurement was performed three times and the mean value was recorded for analysis.

Disabilities of the Arm, Shoulder and Hand Questionnaire (DASH)

Upper extremity–related functional impairment and symptom intensity were measured using the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire. This patient-reported outcome measure was developed to evaluate functional difficulties and symptom burden in various upper limb conditions. The scale includes 30 items rated on a 5-point scale, and total scores are standardized to a 0–100 range, where higher scores reflect greater limitation. The Turkish adaptation of the DASH has shown high internal consistency (Cronbach's α=0.92) and excellent test–retest reliability (ICC=0.97), as reported by Düger et al. [24].

DOI: 10.5455/medscience.2025.10.274

Short Form-12 Health Survey (SF-12)

To evaluate general health-related quality of life, the SF-12 questionnaire—a shortened form of the SF-36 health survey—was utilized. This tool consists of 12 key items and provides two main outcome measures: the Mental Component Summary (MCS) and the Physical Component Summary (PCS). Both scores are scaled from 0 to 100, where higher values reflect a better self-perceived health status. The Turkish adaptation of the SF-12 has demonstrated good reliability and validity, with Cronbach's α coefficients ranging between 0.80 and 0.88 [25].

Statistical Analysis

Data collected in the study were analyzed using the SPSS version 25 (Statistical Package for the Social Sciences). To assess the normality of the data distribution, the Shapiro-Wilk test was applied. A significance level of 0.05 was set for all comparative analyses. Since the variables were found to follow a normal distribution ($p>0.05$), parametric statistical methods were employed. Differences between the two intervention groups (PEG and SEG) at baseline and after treatment were examined using independent-samples t-tests, while within-group pre- and post-intervention comparisons were assessed with paired-samples t-tests. To evaluate the interaction between time and group effects, a two-way repeated-measures ANOVA was applied. Categorical variables were analyzed through chi-square tests. Continuous data are presented as mean ± standard deviation, and categorical data are expressed as frequencies and percentages.

Results

Thirty-two patients were randomly assigned to the PEG and SEG groups. Baseline characteristics are summarized in Table 1. Except for gender, no significant differences were found between the groups regarding age, pain history, or affected shoulder.

Table 1. Comparison of demographic variables by groups

Characteristic		n	Groups		Total	χ^2	p
			PEG	SEG			
Age	30-39 years	n	1	0	1	0.253	0.56[a]
		%	6.3	0.0	3.1		
	40-49 years	n	5	6	11		
		%	31.3	37.5	34.4		
	50-59 years	n	8	6	14		
		%	50.0	37.5	43.8		
	60-65 years	n	2	4	6		
		%	12.5	25.0	18,8		
Gender	Woman	n	12	16	28	**-0.378**	**0.033[c]**
		%	75.0	100.0	87.5		
	Man	n	4	0	4		
		%	25.0	0.0	12.5		
Shoulder	Right	n	9	8	17	0.063	0.723[a]
		%	56.3	50.0	53.1		
	Left	n	7	8	15		
		%	43.8	50.0	46.9		
		%	31.3	12.5	21.9		
Pain duration	3-4 months	n	5	3	8	0.262	0.821[b]
		%	31.3	18.8	25.0		
	5-6 months	n	3	5	8		
		%	18.8	31.3	25.0		
	7-8 months	n	2	3	5		
		%	12.5	18.8	15.6		
	9-10 months	n	1	0	1		
		%	6.3	0.0	3.1		
	11 months	n	4	4	8		
		%	25.0	25.0	25.0		
	2-3 years	n	1	1	2		
		%	6.3	6.3	6.3		

[a]P: student T-test; bP: Mann–Whitney U test; [c]P: Chi-square test; W: Woman; M: Male; SD: standart deviation

 DOI: 10.5455/medscience.2025.10.274

Primary Outcome

Intergroup and intragroup comparisons of VAS scores are presented in Table 2. No statistically significant differences were observed between the groups' baseline (pre-test) VAS scores (p=0.863). However, intragroup analyses revealed statistically significant improvements in VAS scores from pre-test to post-test within each group (PEG: p=0.001, t: 66.015, SEG: p=0.001, t: 34.746). In contrast, intergroup comparisons did not demonstrate a statistically significant difference in post-intervention outcomes (p=0.125, η_p^2=0.077).

Table 2. Descriptive statistics for pre-test and post-test measurement of pain (VAS)

VAS	PEG		SEG		P/effect size (η_p^2)	P/effect size (η_p^2)	
	Mean (SD)		Mean (SD)			t^a	p^a
VAS pre-test	5.94 (2.11)		5.81 (1.94)		F=2.487	t=0.03	p=0.863
VAS post-test	2.75 (1.84)		3.5 (1.75)		p=0.125	t=1.392	p=0.247
Ppair/effect size (η_p^2)	**t=66.015**	**p=0.001^b**	**t=34.746**	**p=0.001^b**	η=0.077		

Bold values indicate that it is statistically significant (p<0.05);SD: Standart deviation; F; Repeated measurement ANOVA; t^a; student T-test; t^b; Paired t-test; η_p^2: Partial eta squared, Effect size: small effect 0.0099; medium effect 0.0588; and large effect; 0.1379; PEG: Proprioceptive neuromuscular facilitation exercise group; SEG: Stabilization exercise group; VAS: Visual analog scale

Secondary Outcomes

Muscle Strength

Intergroup and intragroup comparisons of shoulder muscle strength scores are presented in Table 3. No statistically significant difference was found between the groups in terms of pre-test muscle strength values. However, when comparing pre-test and post-test results within each group, significant improvements were observed in shoulder extension, flexion, abduction/ adduction, and external/ internal rotation muscle groups. In the analysis of between-group differences, a statistically significant improvement was noted in shoulder internal rotation strength in favor of the intervention group (p=0.007, η_p^2=0.221).

Table 3. Intra-group and inter-group comparison of shoulder muscle strength measurements

MMT	PEG		SEG		P/effect size (η_p^2)	P/effect size (η_p^2)	
	Mean (SD)		Mean (SD)			t^a	p^a
Flexion pre-test	4.19 (0.40)		3.88 (0.50)		F=1.216	t=3.788	p=0.061
Flexion post-test	4.94 (0.25)		4.44 (0.63)		p=0.279	**t=1.392**	**p=0.247**
Ppair/effect size (η_p^2)	**t=38.919**	**p=0.001^b**	**t=21.892**	**p=0.001^b**	η=0.039		
Extension pre-test	4.19 (0.40)		4.19 (0.40)		F=1.364	t=0.001	p=1.000
Extension post-test	5.00 (0.00)		4.81(0.40)		p=0.252	t=3.462	p=0.073
Ppair/effect size (η_p^2)	**t=51.212**	**p=0.001^b**	**t=30.303**	**p=0.001^b**	η=0.043		
Abduction pre-test	4.13 (0.5)		3.81 (0.54)		F=0.918	t=2.863	p=0.101
Abduction post-test	5.00 (0.00)		4.50 (0.52)		p=0.346	**t=15.001**	**p=0.001**
Ppair/effect size (η_p^2)	**t=40.001**	**p=0.001^b**	**F=24.694**	**p=0.001^b**	η=0.03		
Adduction pre-test	4.13 (0.5)		3.88 (0.34)		F=1.791	t=2.727	p=0.109
Adduction post-test	4.94 (0.25)		4.44 (0.51)		p=0.191	**t=12.308**	**p=0.001**
Ppair/effect size (η_p^2)	**t=37.836**	**p=0.001^b**	**t=18.134**	**p=0.001^b**	η=0.056		
Erot- pre-test	3.94 (0.57)		3.56 (0.51)		F=3.803	t=3.803	p=0.061
Erot- post-test	4.88 (0.34)		4.13 (0.5)		p=0.061	**t=24.545**	**p=0.001**
Ppair/effect size (η_p^2)	**t=47.535**	**p=0.001^b**	**t=17.113**	**p=0.001^b**	η=0.113		
Irot- pre-test	3.94 (0.57)		3.81 (0.54)		**F=8.497**	t=0.401	p=0.532
Irot- post-test	5.00 (0.00)		4.31 (0.60)		**p=0.007***	**t=20.862**	**p=0.001**
Ppair/effect size (η_p^2)	**t=60.629**	**p=0.001^b**	**t=13.427**	**p=0.001^b**	η=0.221		

Bold values indicate that it is statistically significant (p<0.05);SD: Standart deviation; F; Repeated measurement ANOVA; t^a; student T-test; t^b; Paired t-test; η_p^2: Partial eta squared, Effect size: small effect 0.0099; medium effect 0.0588; and large effect; 0.1379; PEG: Proprioceptive neuromuscular facilitation exercise group; SEG: Stabilization exercise group; MMT: Manual muscle testing; Erot: External rotation; Irot: Internal rotation

Range of Motion

Table 4 summarizes the intergroup and intragroup analyses of shoulder ROM. Baseline ROM values did not differ significantly between the groups. In contrast, intragroup evaluations demonstrated notable improvements in flexion, extension, abduction, adduction, and internal as well as external rotation from pre- to post-test. In the analysis of between-group differences, statistically significant improvements were found in flexion ($p=0.008$, $\eta_p^2=0.210$), abduction ($p=0.003$, $\eta_p^2=0.261$), adduction ($p=0.007$, $\eta^2=0.217$), and external rotation ($p=0.048$, $\eta_p^2=0.124$). No significant difference was observed between groups for internal rotation ($p=0.476$, $\eta_p^2=0.017$).

Table 4. Intra-group and inter-group comparison of ROM measurements

ROM	PEG		SEG		P/effect size (η_p^2)	P/effect size (η_p^2)	
	Mean (SD)		Mean (SD)			t^a	p^a
Flexion pre-test	124.75 (17.95)		122.75(26.76)		**F=7.996**	t=0.062	p=0.806
Flexion post-test	163.44 (13.54)		147.5 (17.14)		**p=0.008**	**t=8.519**	**p=0.007**
Ppair/effect size (η_p^2)	**t=123.22**	**p=0.001^b**	**t=50.431**	**p=0.001^b**	η=0.21		
Extension pre-test	48.75 (9.71)		40.81 (14.58)		F=3.117	t=3.283	p=0.08
Extension post-test	69 (12.97)		53.63 (11.46)		p=0.088	**t=12.631**	**p=0.001**
Ppair/effect size (η_p^2)	**t=46.211**	**p=0.001^b**	**t=18.499**	**p=0.001^b**	η=0.094		
Abduction pre-test	98.69 (21.44)		101.63 (32.1)		**F=10.571**	t=0.093	p=0.763
Abduction post-test	149.38 (26.7)		127.75 (25.47)		**p=0.003**	**t=5.497**	**p=0.026**
Ppair/effect size (η_p^2)	**t=90.035**	**p=0.001^b**	**F=23.918**	**p=0.001^b**	η=0.261		
Adduction pre-test	36.38 (9.2)		37.06 (12.77)		**F=8.312**	t=0.031	p=0.862
Adduction post-test	56.25 (12.52)		47.75 (11.25)		**p=0.007**	t=4.082	p=0.052
Ppair/effect size (η_p^2)	**t=77.798**	**p=0.001^b**	**t=22.496**	**p=0.001^b**	η=0.217		
Erot- pre-test	41.19 (28.49)		40.13 (26.57)		**F=4.263**	t=0.012	p=0.914
Erot- post-test	76.75 (18.12)		60.13 (18.95)		**p=0.048**	**t=6.433**	**p=0.017**
Ppair/effect size (η_p^2)	**t=44.525**	**p=0.001^b**	**t=14.083**	**p=0.001^b**	η=0.124		
Irot- pre-test	67.5 (22.11)		53.63 (25.16)		**F=0.52**	t=2.746	p=0.108
Irot- post-test	100.19 (18.85)		81.56 (14.79)		p=0.476	**t=9.669**	**p=0.004**
Ppair/effect size (η_p^2)	**t=49.274**	**p=0.001^b**	**t=35.994**	**p=0.001^b**	η=0.017		

Bold values indicate that it is statistically significant (p<0,05); VAS: Visual analog scale, SD: Standart deviation; F; Repeated measurement ANOVA; t^a; student T-test; t^b; Paired t-test , η_p^2: Partial eta squared, Effect size: small effect 0.0099; medium effect 0.0588; and large effect; 0.1379; PEG: Proprioceptive neuromuscular facilitation exercise group; SEG: Stabilization exercise group, ROM: Range of motion

Functional status

Table 5 presents the intergroup and intragroup comparisons of Shoulder Muscle Strength and DASH (Disabilities of the Arm, Shoulder and Hand) scores. Baseline DASH scores did not differ significantly between the groups. Within-group analysis showed significant improvements from pre-test to post-test in both groups. Nevertheless, the comparison of post-test DASH scores revealed no statistically significant differences between the groups ($p=0.163$, $\eta_p^2=0.064$).

Table 5. Intra- and inter-group comparison of DASH scores

DASH	PEG		SEG		P/effect size (η_p^2)	P/effect size (η_p^2)	
	Mean (SD)		Mean (SD)			t^a	p^a
DASH pre-test	49.43 (12.78)		53.02 (16.32)		F=2.049	t=0.481	p=0.493
DASH post-tets	18.8 (13.55)		28.49 (12.05)		p=0.163	**t=4.569**	**p=0.041**
Ppair/effect size (η_p^2)	**t=103.509**	**p=0.001^b**	**t=66.415**	**p=0.001^b**	η=0.064		

Bold values indicate that it is statistically significant (p<0,05); VAS: Visual analog scale, SD: Standart deviation; F; Repeated measurement ANOVA; t^a; student T-test; t^b; Paired t-test , η_p^2: Partial eta squared, Effect size: small effect 0.0099; medium effect 0.0588; and large effect; 0.1379; PEG: Proprioceptive neuromuscular facilitation exercise group; SEG: Stabilization exercise group; DASH: Disabilities of the Arm, Shoulder, and Hand Questionnaire

 DOI: 10.5455/medscience.2025.10.274

Quality of Life

Table 6 displays the intergroup and intragroup comparisons of SF-12 outcomes. At baseline, no significant differences were observed between the groups in either the physical or mental component scores. Intragroup analysis demonstrated significant improvements in both subscales (physical and mental) from pre- to post-test within each group. Despite these within-group gains, the comparison of post-test SF-12 scores showed no statistically significant differences between the groups ($p=0.163$, $\eta_p^2=0.064$).

The analysis revealed that both PNF and shoulder stabilization exercises led to significant improvements in patients with AC across multiple clinical outcomes. Notable gains were observed in pain reduction, shoulder ROM, muscle strength, functional performance, and overall quality of life. When comparing the two interventions, the PNF program produced greater benefits than the stabilization approach, particularly in enhancing shoulder mobility and strengthening the internal rotator muscles.

Table 6. Intra-group and inter-group comparison of SF-12 MC and PC

SF-12	PEG		SEG		P/effect size (η_p^2)	P/effect size (η_p^2)	
	Mean (SD)		Mean (SD)			t[a]	p[a]
SF-12 MC pre-test	44.41 (9.21)		39.22 (11.92)		F=0.014	t=1.899	p=0.178
SF-12 MC post-test	52.74 (7.81)		47.86 (11.06)		p=0.906	t=2.081	p=0.161
Ppair/effect size (η_p^2)	**t=20.634**	**p=0.001[b]**	**t=22.19**	**p=0.001[b]**	η=0.001		
SF-12 PC pre-test	37.31 (5.76)		35.41 (4.4)		F=2.318	t=1.097	p=0.303
SF-12 PC post-test	48.38 (4.78)		42.2 (6.72)		p=0.138	**t=9.004**	**p=0.005**
Ppair/effect size (η_p^2)	**t=30.996**	**p=0.001[b]**	**t=11.658**	**p=0.002[b]**	η=0.072		

Bold values indicate that it is statistically significant (p<0,05); VAS: Visual analog scale, SD: Standart deviation; F; Repeated measurement ANOVA; t[a]; student T-test; t[b]; Paired t-test , η_p^2: Partial eta squared, Effect size: small effect 0.0099; medium effect 0.0588; and large effect; 0.1379; PEG: Proprioceptive neuromuscular facilitation exercise group; SEG: Stabilization exercise group; SF-12: Short form 12; SF-12 MC: Short form 12 mental score; SF-12 PC: Short form 12 physical score

Discussion

Our study was conducted to investigate the effects of PNF and shoulder stabilization exercises on pain, range of motion, muscle strength, functionality and quality of life in patients with AC.

Based on the findings of this study, patients with AC demonstrated clinical improvements in both intervention groups. When comparing the groups, the PNF group showed significantly greater gains in shoulder flexion, abduction, adduction, and external rotation, as well as in internal rotator muscle strength, relative to the stabilization group. No significant between-group differences were observed in the remaining outcome measures.

PNF, designed to enhance joint synchronization, movement control, and mobility through agonist–antagonist activation, has been associated with broad clinical benefits across patient populations: reducing pain in knee osteoarthritis; improving quality of life in subacromial impingement syndrome; decreasing dyspnea and improving cervicoscapular mobility when combined with respiratory exercises in COPD; alleviating pain and enhancing function in low back pain; and, following total knee arthroplasty, reducing pain, increasing range of motion, and improving gait [26].

In order for the shoulder to perform its functions in the best way, both the scapula and the shoulder joint must participate in the movement simultaneously. With the PNF technique, upper extremity patterns come into play together with scapular movements. In light of this information, Balcı et al. [19] examined the effects of PNF techniques and classical exercise methods on pain, scapular dyskinesia, ROMand functionality in patients with AC. As a result of the study, although the PNF group was successful in improving ROM, pain and function, they did not report its superiority over other treatment modalities. Another study comparing traditional physical therapy with PNF exercises was conducted by Akbaş et al. [27]. In the control group, conventional physiotherapy combined with a home exercise program (including wall and cane exercises) was administered, while the PNF group received additional upper extremity and scapular PNF patterns alongside conventional physiotherapy. The results indicated that PNF was more effective than the control intervention in improving night pain and enhancing flexion and abduction range of motion. However, no significant differences were observed between the groups regarding resting pain, activity-related pain, or internal and external rotation.

Mishra et al. [14] examined the effects of conventional physiotherapy and scapular PNF exercises applied together with conventional physiotherapy on pain and disability in patients with AC, and they reported that both groups were effective in reducing pain and disability; in the analysis of differences between groups, they reported that PNF provided more improvement compared to conventional treatment applied alone. In our study, similarly, the cases in both groups benefited from the treatments, but it was observed that PNF exercises were superior to other shoulder stabilization exercises in developing shoulder internal rotation muscle strength and shoulder range of motion.

There are also studies in the literature comparing PNF with different treatment methods in patients with AC. Deepika et al. [28] compared the effects of Spencer muscle energy technique and PNF exercises in patients with AC. Both received interference treatment initially, then 30 minutes of Spencer muscle energy technique was applied to one group and 20 minutes of PNF was applied to the other group. At the end of this study, as in our study, improvements were provided in both techniques used, but it was stated that Spencer muscle energy technique was more successful than PNF. Lin et al. [9], who used another method, which they wanted to compare manual therapy (MT) and PNF exercises in patients diagnosed with AC. In addition to extracorporeal shock wave and ultrasound treatment for 4 weeks, manual therapy was applied to one group and PNF exercises to the other group As a result of the study, pain relief in the PNF group was significantly better than in the MT group; In the ROMmeasurement made 2 weeks after the treatment, they reported that the PNF group improved more than the MT group in all angles. Yang et al. [29] examined the effects of the Mulligan technique and the PNF technique on pain and movement restriction in patients with AC. They included 20 patients who were randomly assigned to two groups, each receiving treatment five times per week over a six-week period. Findings demonstrated that both interventions produced significant improvements in shoulder flexion, abduction, and internal and external rotation, consistent with the results of our study. While pain reduction was observed in both groups, the Mulligan technique proved to be more effective than PNF in decreasing pain and enhancing ROM.

In the treatment of AC, PNF exercises can be used alone or in combination with other treatment options. PNF exercises can be beneficial in patients with AC when combined with mobilization techniques. Student et al. [30] investigated the effects of PNF and mobilization techniques on pain and joint range of motion. The control group underwent joint mobilization, while the experimental group received mobilization plus PNF, applied five times per week for four weeks. Although both groups improved significantly, mobilization with PNF proved superior in enhancing ROM and reducing pain and stiffness. Byung Ki Lee [31] applied PNF exercises together with deep breathing exercises in a single case study (A 46-year-old patient was treated with 3 weekly sessions for 8 weeks) and improvements were observed in pain and ROM scores at the end of the treatment. In our study, improvements were observed in ROM scores in the group where PNF exercises were applied, but no significant improvement was observed in pain scores.

Inadequate scapula and shoulder stabilization can cause dysfunction in the kinetic chain, shoulder injuries or different shoulder pathologies. Stabilization of the scapula depends on the surrounding muscles and is responsible for dynamically positioning the glenoid for effective glenohumeral joint movement [32]. Shoulder stabilization exercises are used to improve shoulder stabilization and eliminate movement dysfunctions due to abnormal scapular placement and abnormal dynamic control by maintaining effective length and tension of upper extremity movement with active movements of the muscles surrounding the scapula [33]. Stabilization exercises can be used in subacromial impingement syndrome, shoulder periarthritis , chronic neck pain, scapular dyskinesia, shoulder dislocation and many orthopedic diseases [9].

Jeong et al. [34] studied the effects of shoulder stabilization exercises and performed shoulder stabilization exercises (SSE) only and an intervention group; shoulder stabilization exercises combined with diaphragmatic breathing (DB) (40 healthy male participants for 4 weeks with telerehabilitation during the COVID-19 pandemic). Significant progress was observed in neck pain, posture, and function across both groups. The addition of diaphragmatic breathing in the intervention group produced greater benefits, particularly in forward head posture and shoulder balance, and it was recommended that diaphragmatic breathing exercises be included in stabilization exercises in posture disorders or other upper extremity syndromes. In addition, the effects of stabilization exercises were examined in patients with AC. In the study of Derya ÇELİK [35], patients with AC were treated and divided into two groups as Group I and Group II. TENS and cold application from physical therapy modalities were applied, then, glenohumeral joint ROMexercises were shown to both groups. The physiotherapist applied manual stretching exercises, PNF, stage I gliding exercises and gave home exercises in the following sessions according to the functional status of the patient. In addition to these, stabilization exercises were performed to Group II. In the intra-group evaluations; statistically significant results were obtained in both groups in pain, ROM and functionality scores at the end of the 6th and 12th weeks. In the inter-group evaluations; the pain at the 6th week and ROM values at the end of the 12th week were found to be superior in Group II compared to Group I. When functionality was examined, no difference was found between the groups at 0, 6 and 12 weeks. This and many other studies recommend shoulder ROMexercises together with scapulothoracic exercises in the treatment of AC. This study is similar to our research in terms of methods, but in our study, we applied PNF techniques to one group and stabilization exercises to the other group in addition to conventional treatment. Our study is important in terms of seeing whether we achieve the same level of improvement when only stabilization exercises are applied in addition to conventional treatment instead of other techniques.

Gulwani et al. [36] conducted a study to evaluate the effects of scapular stabilization exercises, applied in addition to conventional physiotherapy, on pain, functional capacity, and shoulder ROMin patients with AC, with one group receiving only conventional physiotherapy and the other receiving both interventions over a two-week period, six days per week. As a result of the treatment, both groups gave statistically significant results, but it was observed that the stabilization group was more effective in reducing pain and improving shoulder ROM among the groups. Another study comparing the effectiveness of conventional physiotherapy with stabilization exercises was conducted by Tabassum [37], and the patients' pain, ROMand shoulder functions were evaluated. As a result of the study, the scapular stabilization group was found to be superior to the group that received only traditional physiotherapy. Dev et al. [38] also compared the effects of stabilization exercises with conventional treatment. As a result of the study, both the control group and the experimental group gave significant results in improving ROM and functional ability. When the values between the groups were examined, the experimental group benefited from the increase in ROM and functionality compared to the control group. There are few studies on shoulder stabilization exercises in patients with AC. We did not come across a study comparing PNF and stabilization methods, so our study differs from other studies.

Karnawat et al. [39] who wanted to examine the effects of stabilization exercises and conventional treatment and applied treatment for 12 weeks. As a result of this study, it was found that the group that applied stabilization exercises showed a decrease in pain, and more improvement in function and external rotation ROMcompared to the group that applied conventional treatment. Jung [40] who conducted a single case study examined the effects of scapular stabilization exercise on shoulder pain, active ROMand changes in the position of the scapula in a 53-year-old female patient with AC. The patient was applied conventional physical therapy and scapular stabilization exercises 3 times a week for 4 weeks. When the evaluations were made before and after the treatment, it was seen that the VAS scale decreased from 7 to 3. Before the treatment, flexion (133), abduction (102), internal rotation (45) and external rotation (53) angles were measured. The study demonstrated that scapular stabilization exercises were effective in alleviating pain, improving range of motion, and correcting scapular positioning in these patients.

Recommendations

From a practical standpoint, integrating PNF techniques into conventional physiotherapy routines could enhance treatment efficacy for patients with adhesive capsulitis, particularly in restoring shoulder movement and muscular control. Future investigations should aim to confirm these results in larger, more diverse populations and over longer intervention periods. Including a control group and analyzing potential moderators—such as limb dominance, disease stage, and symptom duration—would also help to clarify the specific effects and mechanisms underlying each intervention approach.

Limitations

Considering the outcomes of the present study, several directions can be proposed for future investigations. Extending the duration of both PNF and stabilization exercise programs may provide a clearer understanding of their long-term effects on individuals with adhesive capsulitis. Incorporating a control group in future research would also allow for a more precise evaluation of the independent impact of each exercise approach. Moreover, as upper limb dominance could potentially affect the treatment response, it is advisable to include this factor in future statistical analyses to ensure more accurate interpretation of results.

Conclusion

In summary, both exercise programs—PNF and stabilization training—proved to be effective in improving shoulder function, reducing pain, and enhancing daily activity performance in individuals with adhesive capsulitis. Nevertheless, the PNF approach demonstrated superior results in terms of muscle strength and range of motion. These findings suggest that PNF-based exercises may represent a more advantageous therapeutic option when aiming to optimize mobility and functional recovery within the rehabilitation process.

Acknowledgements
This article was produced from the Master's thesis conducted by Safiye Gül Özkan under the supervision of Osman Çoban. The authors thank all participants for their voluntary participation in the study.

Ethical Approval
The study was approved by the Üsküdar University Non-Interventional Research Ethics Committee (No: 61351342/December 2022-38; Date: 28 December 2022).

Patient Consent
Informed consent was waived due to the retrospective design.

Conflict of Interest
The authors declare no conflict of interest.

Funding
No financial support was received.

References

1. Ramirez J. Adhesive capsulitis: diagnosis and management. Am Fam Physician. 2019;99:297-300.
2. Fields BK, Skalski MR, Patel DB, et al. Adhesive capsulitis: review of imaging findings, pathophysiology, clinical presentation, and treatment options. Skeletal Radiol. 2019;48:1171-84.
3. Kingston K, Curry EJ, Galvin JW, et al. Shoulder adhesive capsulitis: epidemiology and predictors of surgery. J Shoulder Elbow Surg. 2018;27:1437-43.
4. Nakandala P, Nanayakkara I, Wadugodapitiya S, Gawarammana I. The efficacy of physiotherapy interventions in the treatment of adhesive capsulitis: A systematic review. J Back Musculoskelet Rehabil. 2021;34:195-205.
5. Wang W, Shi M, Zhou C, et al. Effectiveness of corticosteroid injections in adhesive capsulitis of shoulder: a meta-analysis. Medicine (Baltimore). 2017;96:e7529.
6. Wong CK, Levine WN, Deo K, et al. Natural history of frozen shoulder: fact or fiction? A systematic review. Physiotherapy. 2017;103:40-7.
7. Redler LH, Dennis ER. Treatment of adhesive capsulitis of the shoulder. J Am Acad Orthop Surg. 2019;27:e544-54.
8. İğrek S, Çolak TK. Comparison of the effectiveness of proprioceptive neuromuscular facilitation exercises and shoulder mobilization in patients with subacromial impingement syndrome: A randomized clinical trial. J Bodyw Mov Ther. 2022;30:42-52.

9. Lin P, Ma C, Su Z, et al. Effect of proprioceptive neuromuscular facilitation technique on the treatment of frozen shoulder: a pilot randomized controlled trial. BMC Musculoskelet Disord. 2022;23:367.

10. de Sire A, Marotta N, Ferrillo M, et al. Non-surgical and rehabilitative interventions in patients with frozen shoulder: umbrella review of systematic reviews. J Pain Res. 2022;15:2449-64.

11. Panagiotopoulos A, Crowther I. Scapular dyskinesia, the forgotten culprit of shoulder pain and how to rehabilitate. SICOT J. 2019;5:29.

12. Jeon NY, Chon SC. Effect of glenohumeral stabilization exercises combined with scapular stabilization on shoulder function in patients with shoulder pain. J Back Musculoskelet Rehabil. 2018;31:259-65.

13. Wen M, Hu X, Bao G. Scapular dyskinesis-based exercise therapy versus multimodal physical therapy for subacromial impingement syndrome in young overhead athletes with scapular dyskinesis. BMC Sports Sci Med Rehabil. 2025;17:204.

14. Mishra N, Mishra A, Charaniya P. Effect of scapular proprioceptive neuromuscular facilitation on pain and disability in patients with adhesive capsulitis. Int J Yogic Hum Mov Sports Sci. 2019;4:995-1000.

15. Schulz KF, Altman DG, Moher D, et al. CONSORT 2010 statement: updated guidelines for reporting parallel group randomized trials. J Clin Epidemiol. 2010;63:834-40.

16. Faul F, Erdfelder E, Buchner A, et al. Statistical power analyses using G*Power 3.1. Behav Res Methods. 2009;41:1149-60.

17. Mukherjee RN, Kundu S, Das S, et al. Frozen shoulder: A prospective randomized clinical trial. World J Orthop. 2017;8:394.

18. Kalasva NK, Shukla YU. Immediate effect of myofascial release with PNF for subscapularis on glenohumeral external rotation. Indian J Phys Ther. 2014;2:30-3.

19. Balcı NC, Ergin ES, Baltacı G, et al. Acute effect of scapular PNF techniques and classic exercises in adhesive capsulitis. J Phys Ther Sci. 2016;28:1219-27.

20. Park SI, Choi YK, Lee JH, et al. Effects of shoulder stabilization exercise on pain and functional recovery. J Phys Ther Sci. 2013;25:1359-62.

21. Tashjian RZ, Deloach J, Porucznik CA, et al. Determining the minimal clinically important difference for shoulder scores. J Shoulder Elbow Surg. 2017;26:144-8.

22. Bittmann FN, Brunner F, Bittmann N, et al. Manual muscle testing—force profiles and reproducibility. Diagnostics (Basel). 2020;10:996.

23. Correll S, Field J, Hutchinson H, et al. Reliability and validity of the halo digital goniometer. Int J Sports Phys Ther. 2018;13:707.

24. Duger T, Yakut E, Oksuz C, et al. Turkish version of the DASH questionnaire. Fizyoter Rehabil. 2006;17:99.

25. Kocyigit H, Aydemir O, Fisek G, et al. Turkish version of the SF-36. Turk J Drugs Ther. 1999;12:102-6.

26. Smedes F, Heidmann M, Schaarsberg R, et al. The PNF concept: state of the evidence. Phys Ther Rev. 2016;21:17-31.

27. Akbaş E, Ergin ES, Baltacı G, et al. Effects of additional PNF over conventional therapy. Fizyoter Rehabil. 2015;26:78-85.

28. Deepika B, Sharma S, Verma R, et al. Spencer MET and PNF in adhesive capsulitis. Indian J Physiother Occup Ther. 2024;18:447-52.

29. Yang J, Lee H, Kim S, et al. Mulligan treatment and PNF in frozen shoulder. J Korean Acad Orthop Man Phys Ther. 2006;12:27-36.

30. Student P, Mahendran P, Principal M. Joint mobilization with PNF in adhesive capsulitis. J Chalmeda Anand Rao Inst Med Sci. 2013;6:6.

31. Lee BK. Combined PNF and breathing exercises in frozen shoulder. J Exerc Rehabil. 2015;11:276.

32. Moezy A, Sepehrifar S, Dodaran MS. Scapular stabilization exercise therapy effects. Med J Islam Repub Iran. 2014;28:87.

33. Go SU, Lee BH. Scapular stability exercise effects in office workers. J Phys Ther Sci. 2016;28:2999-3002.

34. Jeong GH, Lee BH. Telerehabilitation and shoulder stabilization exercises. J Clin Med. 2024;13:1612.

35. Celik D. Comparison of two exercise programs in frozen shoulder. Acta Orthop Traumatol Turc. 2010;44:285-92.

36. Gulwani AH. Scapular stabilization in diabetic adhesive capsulitis. Int J Sci Healthc Res. 2020;5:320-33.

37. Tabassum M. Effectiveness of scapular stabilization exercise with conventional physiotherapy among adhesive capsulitis patients attended at Center for the Rehabilitation of the Paralysed (CRP) [PhD thesis]. Dhaka: University of Dhaka; 2018.

38. Dev M, Nizar AM. Efficacy of scapular stabilization techniques in improving range of motion and functional ability in patients with phase II adhesive capsulitis of the shoulder joint. Indian J Physiother Occup Ther. 2012;6:196-200.

39. Karnawat S, Harikesavan K, Venkatesan P. Functional scapular stabilization training. J Manipulative Physiol Ther. 2023;46:86-97.

40. Jung MK. Scapular stabilizing exercise in frozen shoulder: case study. J Korean Acad Orthop Man Phys Ther. 2012;18:83-6.