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# Acute effect of scapular proprioceptive neuromuscular facilitation (PNF) techniques and classic exercises in adhesive capsulitis: a randomized controlled trial

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**Abstract.** [Purpose] The aim of our study was to compare the initial effects of scapular proprioceptive neuromuscular facilitation techniques and classic exercise interventions with physiotherapy modalities on pain, scapular dyskinesis, range of motion, and function in adhesive capsulitis. [Subjects and Methods] Fifty-three subjects were allocated to 3 groups: scapular proprioceptive neuromuscular facilitation exercies and physiotherapy modalities, classic exercise and physiotherapy modalities, and only physiotherapy modalities. The intervention was applied in a single session. The Visual Analog Scale, Lateral Scapular Slide Test, range of motion and Simple Shoulder Test were evaluated before and just after the one-hour intervention in the same session (all in one session). [Results] All of the groups showed significant differences in shoulder flexion and abduction range of motion and Simple Shoulder Test scores. There were statistically significant differences in Visual Analog Scale scores in the proprioceptive neuromuscular facilitation and control groups, and no treatment method had significant effect on the Lateral Scapular Slide Test results. There were no statistically significant differences between the groups before and after the intervention. [Conclusion] Proprioceptive neuromuscular facilitation, classic exercise, and physiotherapy modalities had immediate effects on adhesive capsulitis in our study. However, there was no additional benefit of exercises in one session over physiotherapy modalities. Also, an effective treatment regimen for shoulder rehabilitation of adhesive capsulitis patients should include scapular exercises.

**Key words:** Shoulder, Exercise, Pain

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## INTRODUCTION

Adhesive capsulitis (AC) is an idiopathic disease characterized by fibrosis, decreased volume of the glenoid capsule, and progressive pain with loss of range of motion (ROM)[1, 2)]. Shoulder pain and stiffness are accompanied by severe disability. Although it is generally believed to be a self-limiting condition lasting 2–3 years, some studies have reported that up to 40% of patients have persistent symptoms and stiffness beyond 3 years[3)]. This condition therefore is a serious pathology, which is also known as "frozen shoulder" and it has three phases: the painful stage, the frozen stage, and the thawing stage. Stage 1) The painful stage is characterized by the gradual onset of diffuse shoulder pain that usually lasts one to two months; Stage 2) The frozen stage is characterized by progressive loss of motion that lasts several months to a year or longer. This stage

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also exhibits decreased capsular volume, which can be visualized with MRI, for differential diagnosis; Stage 3) The thawing stage, the final stage, is characterized by gradual improvement of range of motion over several months to years. ROM deficits may continue to be unresolved for more than 3–5 years following the onset of AC[4].

The treatment of AC may be either conservative or surgical. Conservative treatment includes medications, intra-articular injections, exercise programs, and physiotherapy modalities. While, joint mobilization techniques in rehabilitation programs improve the mobility of the joint and soft tissues, researchers have reported different results with regards to pain management consisting of exercises, massage, and physiotherapy modalities[5, 6]. With respect to physiotherapy modalities, a variety of interventions are used; these include heat or ice applications, ultrasound (US), interferential therapy, transcutaneous electrical nerve stimulation (TENS), and laser therapies. The goals of exercise programs consisting of ROM, strengthening and stretching exercises, proprioceptive neuromuscular facilitation (PNF), and mobilizing techniques are to relieve pain resulting from capsular contracture and improve glenohumeral ROM[7–11].

Evaluation of the position of the scapula is very important in the pathologies of the shoulder because these pathologies are responsible for the second and third most common causes of musculoskeletal pain. Abnormal changes in the position of the scapula at different angles of the shoulder indicate a disturbance of the scapulohumeral rhythm, and these changes adversely affect the functions of the upper extremity. The ratio of the scapulohumeral rhythm in healthy subjects should be 2:1 (humerus:scapula). In the pathologies limiting the movements of the glenohumeral joint, this rhythm can be reversed. Shoulder pathologies, such as AC and subacromial impingement, can lead to changes in the position of the scapula[12, 13]. Even though scapular alterations have been assessed in patients with frozen shoulder, treatment programs were focused on pain relief and improvement in ROM. Scapular exercises were not included in the programs even though the scapula plays several roles in facilitating optimal shoulder function[14].

PNF is a treatment concept with four theoretical mechanisms, referred to as autogenic inhibition, reciprocal inhibition, stress relaxation, and the gate control theory, that enhance ROM and muscle activation[15, 16].

PNF has been reported to be effective in relieving pain and improving functional abilities. PNF methods, particularly those involving reciprocal activation of the agonist and antagonist to the desired motion, provide the greatest potential for muscle functioning[17–19]. Among therapeutic approaches, joint mobilization using PNF has a positive effect on pain, muscle strength, and ROM. Proper function of the upper extremities requires both motion and stability of the scapula[20, 21]. The scapula patterns defined in PNF are activated within the upper extremity patterns and scapular motions together[22]. The effects of PNF on the shoulder have been investigated in some studies[23–30]. However, no previous study has investigated the effects of scapular PNF exercises in AC rehabilitation. Therefore, the aim of this study was to compare the initial effects of scapular PNF techniques and classic exercises with physiotherapy modalities on pain, scapular dyskinesis, shoulder ROM, and functionality in patients with AC.

## SUBJECTS AND METHODS

This study was designed as randomized control trial. Fifty-three subjects (40 females, 13 males) were recruited for this study from the Baskent University Department of Physical Medicine and Rehabilitation outpatient clinic between March to July 2014. Our inclusion criteria were as follows:

- Diagnosed as unilateral AC (Stage II) with magnetic resonance imaging by a doctor
- Pain in the shoulder for at least 3 months

Our exclusion criteria were as follows:

- History of shoulder surgery or manipulation under anesthesia
- Neurologic deficits affecting shoulder functioning during daily activities
- Pain or disorders of the cervical spine, elbow, wrist, or hand
- Other pathological conditions involving the shoulder (rotator cuff tear, tendinitis, etc.)

Subjects were randomly allocated to three groups: PNF and physiotherapy modalities (PNF group, n=18), a classic exercise group and physiotherapy modalities (classic exercise group, n=18), and only physiotherapy modalities (control group, n=17). Simple randomization and a random-number table were used as the method of sequence generation for patients. A flow diagram of the study is shown in Fig. 1. The same therapist evaluated all the patients, while another therapist applied the intervention methods. The therapist who applied the interventions was experienced in AC treatment and also had a PNF certificate.

The study has been approved by Institutional Ethics Committee of Baskent University (KA13/231). All subjects received an explanation about the purpose and test procedures involved in the study before enrollment. Each subject was informed about the study and gave written informed consent to participate.

In the PNF group, scapular PNF was applied by a trained therapist in two diagonals, anterior elevation and posterior depression (Fig. 2A and 2B, respectively) and posterior elevation and anterior depression (Fig. 2C and 2D, respectively) with 20 repetitions. Patients lay on the unaffected side while the therapists stood in the line of desired motion. Firstly, the therapist gave preparatory instructions. In the beginning of the pattern, the therapist pulled the scapula to the elongated position and then gave instructions for the desired movement. Rhythmic initiation and repeated contractions facilitation techniques were applied in all patterns. These techniques are the best matched scapular facilitation techniques of the PNF agonistic techniques.

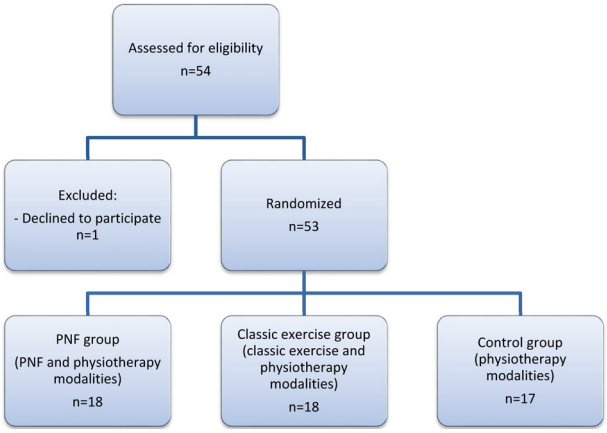


**Fig. 1.** Flow diagram of the process of allocation of subfects to the three groups

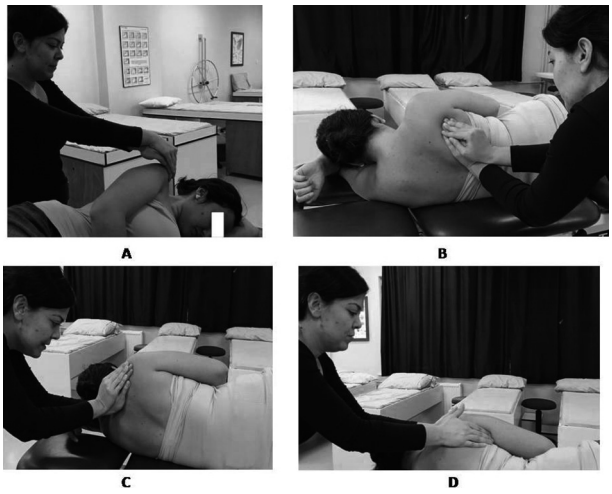


**Fig. 2.** A) Anterior elevation of the scapula, B) posterior depression of the scapula, C) posterior elevation of the scapula, D) anterior depression of the scapula

The rhythmic initiation technique teaches the motion, helps the patient to relax, improves coordination, and normalizes the motion. The repeated contractions technique increases active range of motion and strength and guides the patient's motion towards the desired motion. The rest interval between repetitions was 20 seconds[12, 30].

The therapist applied a hot pack, TENS, and US before scapular PNF. The hot pack was applied to the shoulder region for 20 minutes[31]. Conventional TENS (TensMed 911, Enraf-Nonius B.V., Delft, The Netherlands) was applied to painful sites of shoulder for 20 minutes[32]. The TENS unit was set to a frequency of 100 Hz, a pulse duration of 60 μsn, and a comfortable intensity. Therapeutic US (Sonopuls 590, Enraf-Nonius B.V., Delft, The Netherlands) was applied with a 1 MHz US head, 5 $cm^2$ effective radiating area (ERA), and 1.5 $W/cm^2$ dosage for 3 minutes. In the classic exercise group, the physiotherapy modalities were applied using the same procedure as described above. After the physiotherapy modalities, stretching strengthening exercises were assigned to the patients. One set of stretching exercises including wand and Codman pendulum exercises was performed, with 4 repetitions for each exercise. One set of strengthening exercises including scapular elevation, adduction (posture), and scapular stabilization exercises with an exercise ball were also performed with 20 repetitions for each exercise.

In the control group, the therapist applied physiotherapy modalities using the same procedure as described above. No exercise program was carried out for this group.

In all groups, sociodemographic data were recorded before the study. Pain intensity, scapular dyskinesis, ROM, and function were assessed before and immediately after the one-hour intervention. Pain intensity was assessed with Visual Analog Scale (VAS)[33]. Each subject was asked to mark a 10 cm vertical line on the VAS to indicate the perceived level of pain intensity when active. No pain was indicated with a value of 0 cm, and extreme pain was indicated with a value of 10 cm. The VAS was measured as the distance from 0 to the subject's mark[34]. The Lateral Scapular Slide Test (LSST) was used to assess scapular dyskinesis[35]. This test was designed to evaluate scapular asymmetry under varying loads. In accordance with the method of Kibler, three test positions were used. For test position one (LSST-1), the subjects were instructed to keep their upper extremities relaxed at their sides. For test position two (LSST-2), the subjects were instructed to actively place both hands on the ipsilateral hips, and consequently, the humerus was positioned in medial rotation at 45° of abduction in the coronal plane. For test position three (LSST-3), the subjects were instructed to actively extend both elbows and to elevate both upper extremities to 90° in the coronal plane with maximal internal rotation. In this procedure, the distance between inferior aspect of the inferior angle of the scapula and the closest spinous process in the same horizontal plane was measured bilaterally with a tape measure for all three positions. A difference of 1.5 cm or more in any of the three positions was considered a positive result of the LSST[36, 37]. Active shoulder flexion and abduction ROM were assessed with a universal goniometer. Patients were tested in the supine position. Each subject was assessed by the same physiotherapist throughout the trial[38]. The Simple Shoulder Test (SST) was used to assess the functional limitations of the affected shoulder in the context of the patient's activities of daily living. The SST consists of 12 questions with yes (1) or no (0) response options. It has 2 questions related to pain, 7 questions related to function, and 3 questions related to ROM. The score is sum of the points for the "yes" and "no" answers. The SST has been shown to be useful in determining pretreatment shoulder function and in evaluating functional gains and losses over time[39, 40].

The sample size was determined based on statistical power analysis procedures using the PASS 2005 software (NCSS, Kaysville, UT, USA). A power analysis indicated that 13 subjects for each group were needed with 90% power and a 5%

type 1 error. Allowing for a dropout rate of 20% drop out rate for the study, we recruited 18 subjects for each group in order to ensure 90% power. The power analysis for our study showed a power of 90% with scapular dyskinesis as the primary outcome.

The statistical software IBM SPSS Statistics SPSS 20.0 (IBM Corp., Armonk, NY, USA) was used for calculations. All values were presented as mean±standard deviation values and frequencies. The results of homogeneity (Levene's Test) and normality tests (Shapiro Wilk Test) were used to decide which statistical methods to apply in comparison of the study groups. According to these tests results, parametric test assumptions were not available for some variables, so comparisons of two dependent groups were obtained by Wilcoxon test, and comparisons of the three independent groups were analyzed by the Kruskal Wallis test. Repeated measures of variance were analyzed by Mauchly's sphericity test and Box's Test of Equality of Covariance Matrices. For comparisons of means of repeated measures, repeated measures analysis of variance was used. Greenhouse-Geisser correction or Huynh-Feldt correction was used for corrections to the degrees of freedom. The corrected Bonferroni test was used for multiple comparisons. Categorical data were analyzed with Fisher's Exact Test and the chi-square test. If expected outcome was less than 25% of cells in cases, for inclusion, in the analysis of those cells, "Monte Carlo Simulation Method" and the values were determined[41]. For all statistical analyses, the alpha level was set a priori at $p < 0.05$.

## RESULTS

Sociodemographic and clinical characteristics of the patients are shown in Table 1. There were significant differences in VAS results in the PNF and control groups ($p<0.05$), but not in the classic exercise group ($p>0.05$). After the intervention, the VAS results showed no significant differences between any groups ($p>0.05$) (Table 2). The LSST results of the groups before and after the intervention showed no significant differences shown ($p>0.05$) (Table 3).

We found that there were significant improvements in shoulder ROM in all groups ($p<0.05$). However, shoulder flexion and abduction ROM results showed no significant difference between groups after the intervention ($p>0.05$) (Tables 4 and 5).

Before and after the intervention, there were statistically significant differences in the SST results of all the groups ($p<0.05$). After the intervention, the SST results showed no significant difference between the groups ($p>0.05$) (Table 6).

## DISCUSSION

AC is a disease of uncertain etiology characterized by shoulder joint pain and progressive limitation of both active and passive motion in the affected shoulder[42–44]. With this as the background, the aim of our study was to compare the immediate effects of scapular PNF and classic exercises with physiotherapy modalities on pain, scapular dyskinesis, shoulder ROM, and function. According to our results, both scapular PNF exercises and classic exercise approaches combined with physiotherapy modalities were effective for improving shoulder functioning and ROM immediately. The approaches applied in the PNF and control groups were effective for reducing pain intensity, but no significant effect was found on pain intensity in the classical exercise group. On the other hand, none of the interventions had an effect on scapular dyskinesis. Significant differences were not found among the groups. We did not find additional benefits of exercises over the physiotherapy modalities in one session. This is the first study that compare initial effects of different exercises in AC.

Approximately 70% to 90% of patients with stiff shoulders respond well to nonsurgical intervention[45, 46]. It is widely accepted that physiotherapy and stretching exercises should be used in conservative management of AC. In a recent systematic review of the effectiveness of physiotherapy interventions, therapeutic exercises and mobilization were strongly recommended for reducing pain and improving ROM and function in patients with stage 2 and 3 of AC[47]. Simple home exercise programs have been shown to be effective, whereas other clinicians suggest more intensive supervised physiotherapy. A prospective study with a 2 year follow-up compared intensive physiotherapy including passive stretching and manual mobilization with supportive therapy and exercises within pain limits. The study found that exercise within pain limits were more effective than the intensive program[48]. Moist heat, anti-inflammatory medication, and a physician-directed rehabilitation program were shown to consistently result in resolution of symptoms[49]. A retrospective study by Shaffer et al.[50] indicated that following an average of six months of physiotherapy (Codman's exercises, US, TENS, passive joint mobilization, and strengthening exercises), statistically significant improvements in active ROM were achieved (99% flexion, 101% abduction, 62% external rotation). On the other hand, Rizk et al.[51] noted that only 60% of their patients treated with physiotherapy achieved the ability to sleep pain-free after 5 months, and Hazleman[52] reported that 33% of their patients reported increased pain after treatment with physical therapy and that only 50% reported significant improvement after treatment with exercises. In our study, classic exercise approaches including wand exercises, Codman pendulum exercises, scapular elevation and adduction exercises, and scapular stabilization exercises with an exercise ball combined with therapeutic modalities were effective for improving shoulder functions and ROM compared with pretreatment results. However, there were no statistically significant differences pain intensity in this group compared with the pretreatment scores. This may be due to the exercises that were performed, which included ROM exercises for the shoulder that were aggravate pain.

Lee et al.[17] stated that PNF with general physiotherapy techniques (a hot pack for 20 minutes, US therapy for 5 minutes, and TENS for 20 minutes) were effective for improving pain and function in myofascial pain syndrome. They applied the hold-relax PNF technique for relaxing the upper trapezius muscle and stabilizing reversal PNF techniques for scapula

**Table 1.** Sociodemographic and clinical characteristics of the patients

| | PNF group (n=18) | Classic exercise group (n=18) | Control group (n=17) |
|---|---|---|---|
| Age, years (X±SD) | 56.7±7.7 | 58.1±8.4 | 58.6±11.3 |
| BMI (kg/m$^2$) (X±SD) | 26.7±3.0 | 28.5±3.5 | 28.0±3.9 |
| Gender, n (%) | | | |
| Female | 14 (77.8) | 15 (83.3) | 11 (64.7) |
| Male | 4 (22.2) | 3 (16.7) | 6 (35.3) |
| Dominant side, n (%) | | | |
| Right | 16 (88.9) | 14 (77.8) | 6 (94.1) |
| Left | 2 (11.1) | 4 (22.9) | 1 (5.9) |
| Affected extremity n (%) | | | |
| Right | 11 (61.1) | 7 (38.9) | 13 (76.5) |
| Left | 7 (38.9) | 11 (61.1) | 4 (23.5) |

SD: standard deviation; n: number; BMI: body mass index

**Table 2.** Effect of treatment methods on VAS results in all groups

| | VAS (cm) | Mean | Std. error | 95% confidence interval | |
|---|---|---|---|---|---|
| | | | | Lower bound | Upper bound |
| PNF group (n=18) | BI | 6.07 | 0.66 | 4.75 | 7.40 |
| | AI | 4.16 | 0.62 | 2.91 | 5.41 |
| Classic exercise group (n=18) | BI | 4.67 | 0.66 | 3.35 | 6.00 |
| | AI | 3.87 | 0.62 | 2.63 | 5.12 |
| Control group (n=17) | BI | 6.55 | 0.67 | 5.18 | 7.91 |
| | AI | 4.22 | 0.63 | 2.94 | 5.50 |

BI: before intervention; AI: after intervention

**Table 3.** LSST results of the groups before and after the interventions

| | | | PNF group (n=18) | Classic exercise group (n=18) | Control group (n=17) | Total |
|---|---|---|---|---|---|---|
| LSST BI | Dyskinesis− | n | 7 | 16 | 8 | 31 |
| | | % within BI | 22.6% | 51.6% | 25.8% | 100.0% |
| | | % within group | 38.9% | 88.9% | 47.1% | 58.5% |
| | Dyskinesis+ | n | 11 | 2 | 9 | 22 |
| | | % within BI | 50.0% | 9.1% | 40.9% | 100.0% |
| | | % within group | 61.1% | 11.1% | 52.9% | 41.5% |
| LSST AI | Dyskinesis− | n | 10 | 15 | 9 | 34 |
| | | % within BI | 29.4% | 44.1% | 26.5% | 100.0% |
| | | % within group | 55.6% | 83.3% | 52.9% | 64.2% |
| | Dyskinesis+ | n | 8 | 3 | 8 | 19 |
| | | % within BI | 42.1% | 15.8% | 42.1% | 100.0% |
| | | % within group | | | | 35.8% |
| Total | | n | 18 | 18 | 17 | 53 |
| | | % within AI | 34.0% | 34.0% | 32.1% | 100.0% |
| | | % within group | 100.0% | 100.0% | 100.0% | 100.0% |

BI: before intervention; AI: after intervention; dyskinesis−: subjects with no scapular dyskinesis; Dyskinesis+: Subjects with scapular dyskinesis

**Table 4.** Effect of treatment methods on shoulder flexion ROM results in all groups

| Group | Flexion (°) | Mean | Std. error | 95% confidence interval | |
|---|---|---|---|---|---|
| | | | | Lower bound | Upper bound |
| PNF group (n=18) | BI | 143.0 | 4.0 | 134.8 | 151.1 |
| | AI | 151.8 | 3.8 | 144.1 | 159.5 |
| Classic exercise group (n=18) | BI | 144.4 | 4.0 | 136.3 | 152.5 |
| | AI | 154.6 | 3.8 | 146.9 | 162.3 |
| Control group (n=17) | BI | 127.6 | 4.1 | 119.2 | 135.9 |
| | AI | 137.2 | 3.9 | 129.3 | 145.2 |

BI: before intervention; AI: after intervention

**Table 5.** Effect of treatment methods on shoulder abduction ROM results in all groups

| Group | Abduction (°) | Mean | Std. error | 95% confidence interval | |
|---|---|---|---|---|---|
| | | | | Lower bound | Upper bound |
| PNF group (n=18) | BI | 111.9 | 4.9 | 101.9 | 121.8 |
| | AI | 119.7 | 5.1 | 109.4 | 129.9 |
| Classic exercise group (n=18) | BI | 131.2 | 4.9 | 121.3 | 141.2 |
| | AI | 141.1 | 5.1 | 130.9 | 151.4 |
| Control group (n=17) | BI | 112.8 | 5.0 | 102.5 | 123.0 |
| | AI | 121.4 | 5.2 | 110.8 | 131.9 |

BI: before intervention; AI: after intervention

**Table 6.** Effect of treatment methods on SST results in all groups

| Group | SST | Mean | Std. error | 95% confidence interval | |
|---|---|---|---|---|---|
| | | | | Lower bound | Upper bound |
| PNF group (n=18) | BI | 6.77 | 0.61 | 5.53 | 8.02 |
| | AI | 8.16 | 0.56 | 7.03 | 9.30 |
| Classic exercise group (n=18) | BI | 6.94 | 0.63 | 5.66 | 8.21 |
| | AI | 8.47 | 0.58 | 7.30 | 9.63 |
| Control group (n=17) | BI | 5.94 | 0.63 | 4.66 | 7.21 |
| | AI | 7.11 | 0.58 | 5.95 | 8.28 |

BI: before intervention; AI: after intervention

muscles. Weon-Sik et al.[24] investigated the effects of scapular pattern and hold-relax technique of PNF on ROM and pain in 30 patients with AC. They treated the patients for 4 weeks and found that PNF was effective for improving ROM and pain. Similarly, we found scapular PNF exercises combined with physiotherapy modalities were effective for improving pain, shoulder function, and ROM. However, these improvements were not directly caused by scapular PNF exercises. We believe that PNF may be effective when performed with a regular rehabilitation program over a long term.

No previous study has evaluated the acute effects of exercise or mobilization in AC with scapular dyskinesis. Recently, several studies have examined the effectiveness of a scapula-based rehabilitation program[9, 53–60]. Van de Velde et al.[56] showed that a 12-week scapular training program resulted in a significant increase in isokinetic scapular muscle strength in healthy adolescent swimmers, and Merolla et al.[58] reported that a strength increase in the glenohumeral external rotators was apparent after a 6-month training program in volleyball players with scapular dyskinesis. The latter study is of particular importance, since it showed that scapular training improved glenohumeral muscle function, specifically that of the external rotators, which are highly stressed during overhead activities. However, both studies mentioned were performed on healthy non-injured overhead athletes. In general, these studies showed better results regarding functional outcome, strength, and patient satisfaction when a scapular approach is implemented in the treatment protocol. If scapular dyskinesis is assessed after long term treatment, the results might differ, because studies have shown that shoulder pain and function were improved after application of an exercise program in long-term treatment.

In conclusion, all groups showed improvements in shoulder motions and functionality. Pain intensity was reduced in the

scapular PNF and control groups, but not in the classic exercise group. There were no change in LSST scores as a result of the interventions. No significant difference was found between the groups in our investigation of the immediate effects of the treatment methods. Although stretching exercises are very important in AC, we did not apply stretching in this study because scapular PNF patterns and techniques affect shoulder ROM by enhancing the scapular rhythm. Further studies should be conducted compare scapular agonistic techniques with shoulder stretching exercises.

An effective treatment regimen for shoulder rehabilitation should include therapies targeting scapular function. Exercises for scapular motion may be useful for patients with AC. Further studies are needed to investigate long-term effects of PNF exercises. Among scapular PNF techniques, upper extremity PNF patterns with hold-relax and contact-relax techniques are frequently used in clinics to relieve pain and to increase the ROM of joints. In future studies, exercise programs that apply scapular and upper extremity patterns with different techniques may be used for AC.

A limitation of this study was that it evaluated only the initial effects of scapular PNF and classic exercises. Also, the time course of these effects should be investigated by comparing all groups. Another limitation of our study was the measurement of shoulder ROM in only 2 planes; however, limitation of internal and external rotation of the shoulder is more common in AC, and we did not evaluate shoulder rotation ROM.

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