Research Article

Effects of Scapular Proprioceptive Neuromuscular Facilitation (PNF) Technique and Wax Therapy among Periarthritis Shoulder Patients

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Abstract

Background: Periarthritis shoulder is a process usually begins with an injury or stiffness of the soft tissues and due to overuse injuries. Joint mobilization is an effective intervention for Periarthritis shoulder. Scapular PNF techniques in Periarthritis shoulder is used to decrease intra articular pressure by increasing mobility of the joint capsule and its surrounding soft tissue that results in a reduction of pain and increase range of motion and shoulder function. However the combined effectiveness of Scapular PNF Technique and Wax therapy is unknown. The aim of the study is to find out to compare the effectiveness of Scapular PNF Technique and Wax therapy on patients in reducing pain and increasing range of motion.

Methods: The study was conducted in the Physiotherapy Department of Aarupadai Veedu Medical College with the total of 50 subjects. Subjects were distributed in two groups. Experimental group (25 subjects) is treated with Scapular PNF Technique along with wax therapy. Controlled group (25 subjects) is treated with Shoulder free exercises along with wax therapy. Treatment was given 5 days a week for 4 weeks. Restricted joint range of motion and severity of pain were measured before and after treatment completion by using goniometer and NPRS pain scale respectively.

Results: Results of the present study revealed that there was a significant difference in NPRS pain scale, AROM-GH-Flexion, AROM-GH-Abduction and AROM-GH-External rotation who were treated in group A Scapular PNF Technique along with wax therapy with mean being 3.12, 125.2, 119.4 and 46.4 respectively compared to group B Shoulder free exercises along with wax therapy with mean being 4.56, 116, 117.6 and 34.4 in 4 weeks. Statistical analysis done with using both paired and unpaired “t” test which showed more significant improvement in group A.

Conclusion: On the basis of the results, it can be concluded that, the present study provided evidence to support the use of physical therapy regimen for Periarthritis shoulder in the form Scapular PNF Technique along with wax therapy reduction of pain and improvement of glenohumeral range of motion in terms of NPRS pain scale and AROM respectively. In addition, results support that Scapular PNF Technique showed better result as compared to Shoulder free exercises in 4 weeks.

Keywords: Periarthritis Shoulder, Scapular PNF Technique, Wax therapy, Range of motion, Numerical Pain Rating Scale.

1. Introduction

Periarthritis shoulder, also known as adhesive capsulitis or ‘frozen shoulder’, is a musculoskeletal condition characterised by progressive, often disabling pain and restriction of both active and passive range of motion (ROM) at the glenohumeral joint. The condition results from thickening, contraction and adherence of the joint capsule to the humeral head, producing a global loss of movement that does not follow a single anatomical or dermatomal pattern [1].

Periarthritis shoulder is one of the more commonly encountered shoulder disorders in physiotherapy outpatient practice. Yuvarani et al. [2], in a cross-sectional analysis of nearly 300 outpatients with shoulder pain, reported that the condition is most prevalent between 40 and 60 years of age and that severity is greater among women, and cautioned that individuals presenting with unresolved shoulder pain beyond one month are at increased risk of progressing to established Periarthritis. Idiopathic (primary) Periarthritis has no single identifiable cause, while secondary Periarthritis is commonly associated with diabetes mellitus, thyroid dysfunction, cardiovascular disease, rotator cuff pathology, or a period of immobilisation following trauma or surgery.

The natural history of the condition has classically been described as passing through three overlapping stages the freezing (painful) stage, the frozen (stiffness) stage and the thawing (recovery) stage with the overall course

frequently extending well beyond a year if left untreated. Griggs et al. [3] followed patients managed non-operatively and found that although the majority regained functional motion over time, a meaningful proportion were left with residual pain and stiffness, underlining the value of active physiotherapy intervention rather than a purely expectant approach. Patients with diabetes mellitus in particular have been shown to experience a more resistant and prolonged clinical course; Viswanath Reddy et al. [4] specifically studied diabetic subjects with adhesive capsulitis and demonstrated that a structured combination of thermotherapy and manual mobilisation produced measurable gains in pain, ROM and shoulder function in this more treatment-resistant subgroup.

Clinically, patients typically present with a dull, deep aching pain that characteristically worsens at night, together with progressive restriction of shoulder movement most marked in external rotation and abduction. Because the shoulder is central to overhead reach, dressing and grooming, this loss of motion translates directly into reduced function and quality of life. Tveita et al. [5], examining the Shoulder Pain and Disability Index in patients with adhesive capsulitis, confirmed that both the pain and disability domains of the index are meaningfully and independently affected in this population, supporting the use of a combined pain-and-ROM outcome framework as adopted in the present study rather than relying on either measure alone.

Among the physiotherapeutic techniques used to restore motion, Proprioceptive Neuromuscular Facilitation (PNF) has gained wide recognition. PNF techniques use diagonal, rotational movement patterns combined with resisted isometric contraction (hold-relax) or contraction of the antagonist (contract-relax) to stimulate the Golgi tendon organ and muscle spindle, producing autogenic and reciprocal inhibition that reduces reflexive muscle guarding and allows greater soft-tissue elongation. Hindle et al. [6], reviewing the neurophysiological mechanisms of PNF, concluded that this combination of neural inhibition and mechanical stretch makes PNF a more powerful stimulus for increasing ROM than static stretching alone in a comparable time frame.

Applied specifically to the scapula, PNF patterns of elevation, abduction and upward rotation aim to correct the disturbed scapulohumeral rhythm that is characteristic of Periarthritis shoulder, in which an excessively large share of overall arm elevation is transferred to the scapulothoracic joint to compensate for a stiff, non-compliant glenohumeral capsule. Comuk Balci et al. [7] demonstrated in a randomized controlled trial that a single acute session of scapular PNF produced significantly greater improvement in pain and shoulder ROM in adhesive capsulitis than a classic exercise programme, and Jothiprasanna and Rajeswari [8] similarly reported that scapular PNF technique was effective in restoring functional range of motion in this population findings that provided the direct clinical rationale for including a scapular PNF arm in the present study.

Alongside neuromuscular re-education, superficial heating agents are commonly used to prepare periarticular tissue for mobilisation and to provide short-term analgesia. Wax (paraffin) therapy is a form of conductive thermotherapy in which molten paraffin wax, maintained at approximately 40–44°C, is applied to the affected region by the dip-and-wrap method, delivering slow, uniform and prolonged heat transfer to periarticular structures. This raises local tissue temperature and blood flow, reduces pain and muscle spasm, and increases the extensibility of collagen in the joint capsule and surrounding soft tissue, thereby facilitating the exercise or mobilisation technique that follows. Muddassir Riaz et al. [9], comparing paraffin wax bath therapy with therapeutic ultrasound in the management of post-burn joint contractures, found that paraffin wax combined with stretching and massage produced greater improvement in joint mobility than ultrasound with the same adjuncts, supporting its inclusion as the common thermotherapy modality for both treatment groups in the present study.

Scapular stabilization and mobility-based approaches, more broadly, have also been shown to improve outcomes in adhesive capsulitis independent of the specific technique used. Eapen et al. [10] found that scapular stabilization exercise produced significant improvement in scapular dyskinesis, shoulder ROM, pain and functional status in subjects with adhesive capsulitis, reinforcing the broader principle that treatment directed at the scapulothoracic joint and not the glenohumeral joint alone is an important component of comprehensive shoulder rehabilitation.

While both scapular PNF and wax therapy have individually shown favourable effects on pain and range of motion, there remains limited published evidence directly comparing a scapular PNF-plus-wax-therapy protocol against a conventional free-exercise-plus-wax-therapy protocol within the same trial in patients with Periarthritis shoulder. This gap provided the rationale for the present study, which was designed to compare the effects of Scapular Proprioceptive Neuromuscular Facilitation technique combined with Wax therapy against Shoulder free exercises combined with Wax therapy on pain and range of motion in patients with Periarthritis shoulder, over a 4-week intervention period.

2. Research Methodology

2.1 Study Design

This study was designed as a comparative, two-group experimental study, conducted to evaluate and compare the effects of Scapular Proprioceptive Neuromuscular Facilitation (PNF) technique combined with Wax therapy against Shoulder free exercises combined with Wax therapy in patients with Periarthritis shoulder.

2.2 Study Setting

The study was conducted in the Physiotherapy Outpatient Department (OPD), Aarupadai Veedu Medical College and Hospital (AVMC), Kirumampakkam, Puducherry.

2.3 Study Duration

Each subject received a total intervention period of 4 weeks (5 treatment sessions per week), with outcome measures recorded at two time points pre-test (baseline, prior to the first session) and post-test (at the end of the 4th week, after the final session).

2.4 Sampling Method and Sample Size

Randomised sampling method was used to recruit subjects from among patients attending the Physiotherapy OPD with a clinical diagnosis of Periarthritis shoulder. A total of 50 subjects who satisfied the inclusion and exclusion criteria were selected and then allocated equally into two groups of 25 subjects each Group A (Scapular PNF technique with Wax therapy) and Group B (Shoulder free exercises with Wax therapy).

2.5 Variables

Dependent variables

- Pain
- Range of Motion (ROM) Flexion, Abduction, External Rotation

Independent variables

- Scapular PNF Technique
- Wax Therapy
- Shoulder Free Exercises

2.6 Outcome Measures

Pain intensity was measured using the Numerical Pain Rating Scale (NPRS), an 11-point scale ranging from 0 (‘no pain’) to 10 (‘worst pain imaginable’), on which the subject verbally rates the average intensity of shoulder pain experienced over the preceding 24 hours. Farrar et al. [19] established the NPRS as a valid and clinically responsive measure of chronic musculoskeletal pain intensity, and it was selected for this study for its simplicity of administration, its established reliability, and the ease with which it can be repeated at multiple time points without the need for specialised equipment.

Shoulder ROM flexion, abduction, and external rotation was measured using a Universal Goniometer, with the subject positioned according to standard testing procedure for each movement (supine for flexion and abduction; supine with the shoulder abducted to 90° and elbow flexed to 90° for external rotation), the fulcrum aligned over

the relevant bony landmark, and both arms of the goniometer aligned with the reference segments. Hayes et al. [20] evaluated the reliability of goniometric measurement of shoulder ROM and confirmed it to be an acceptable and reproducible clinical method when a standardized testing position and consistent examiner are used, both of which were maintained throughout this study to minimise measurement error.

Table 6: Outcome Measures and Assessment Tools

Variable	Measurement Tool	Timing
Pain	Numerical Pain Rating Scale (NPRS)	Pre-test and Post-test (4 weeks)
Range of Motion	Universal Goniometer	Pre-test and Post-test (4 weeks)

2.7 Selection Criteria

2.7.1 Inclusion criteria

- Both male and female subjects
- Pain in the shoulder for at least 3 months
- Age between 40 and 70 years with primary Periarthritis shoulder
- Unilateral primary Periarthritis shoulder
- Diabetic patients
- Pain and restriction in abduction and external rotation

2.7.2 Exclusion criteria

- History of shoulder surgery or manipulation under anaesthesia
- Open wounds
- Impaired sensation
- Ischaemia
- Rotator cuff rupture
- Hypermobility
- History of recent fracture or severe trauma to the shoulder

2.8 Ethical Considerations

Ethical approval for the study was obtained from the Institutional Research Committee (IRC), Aarupadai Veedu Medical College and Hospital. The purpose, procedure, potential risks and benefits of the study were explained to each subject in their preferred language (English or Tamil) using a Patient Information Sheet, and written informed consent was obtained from every subject prior to enrolment. Participation was entirely voluntary, and subjects were informed of their right to withdraw from the study at any stage without any effect on their ongoing clinical care.

3. Study Procedure

Subjects reporting to the Physiotherapy OPD with a clinical diagnosis of Periarthritis shoulder were screened against the inclusion and exclusion criteria. Eligible subjects who provided informed consent were enrolled and randomly allocated by convenience sampling into Group A or Group B (25 subjects per group). Baseline (pre-test) values of NPRS and goniometric ROM (flexion, abduction, external rotation) were recorded for every subject prior to the first treatment session. Each subject then received their allocated treatment protocol for 5 days a week over 4 consecutive weeks, following which the same outcome measures were re-recorded (post-test) using an identical testing position and procedure to the baseline assessment, in order to minimise measurement bias.

3.1 Treatment Protocol

Both groups received Wax (paraffin) therapy as a common thermotherapy adjunct immediately before their respective exercise protocol, following the direct dip-and-wrap method.

A lint cloth was dipped in molten paraffin wax maintained at approximately 40–44°C and applied over the shoulder region; this was repeated up to 10 times until a thick paraffin coat had formed over the joint, which was then wrapped in a towel and left in place for approximately 15–20 minutes to allow conductive heat transfer into the periarticular soft tissue before its removal and the start of the exercise component. Riaz et al. [9] and Kisner and Colby [22] describe this dip-and-wrap technique as the standard clinical method of applying paraffin wax therapy to proximal joints such as the shoulder, providing slow, uniform superficial heating that increases soft-tissue extensibility and reduces pain and muscle spasm prior to mobilisation or exercise.

3.2 Group A Scapular PNF Technique with Wax Therapy

Position of the patient: Side-lying, with the affected shoulder uppermost.

Position of the therapist: Standing behind the patient.

Method of application: The D1 (diagonal 1) flexion scapular pattern was used, applying the Rhythmic Stabilization technique of PNF, in which the therapist applies alternating isometric resistance to the scapula through small arcs of motion without allowing visible movement, to facilitate co-contraction and stability of the scapular musculature. This technique and its neurophysiological basis autogenic and reciprocal inhibition mediated through Golgi tendon organ and muscle spindle stimulation are described in detail by Adler, Beckers and Buck [21] and by Hindle et al. [6].

The Scapular PNF pattern was applied in three sequential components:

1. Scapular elevation: One hand of the therapist is placed on the patient's shoulder for support/fixation; the other hand is placed on the inferior angle of the scapula, which is guided/resisted through upward movement.
2. Scapular abduction: With the same hand placement, the inferior angle of the scapula is guided/resisted away from the spine (protraction).
3. Scapular upward rotation: With the same hand placement, the inferior angle of the scapula is guided/resisted upward and rotated so that the glenoid fossa faces cranially, reproducing the terminal component of normal upward rotation.

Dosage: Scapular PNF technique was applied for 3 sets of 10 repetitions per session, combined with Wax therapy, 5 days a week for 4 weeks.

3.3 Group B Shoulder Free Exercises with Wax Therapy

Position of the patient: Sitting.

Position of the therapist: Beside the patient.

Following Wax therapy, subjects in Group B performed a standardized programme of active shoulder free exercises, described by Kisner and Colby [22] as an appropriate active-exercise progression for restoring shoulder mobility once acute irritability has been reduced by thermotherapy. The programme comprised:

- Codman's (pendulum) exercise gravity-assisted passive/active-assisted circular and pendular swinging of the affected arm to promote joint distraction and reduce guarding.
- Finger ladder exercise active-assisted progressive shoulder flexion/abduction using a wall-mounted finger ladder to encourage incremental gains in elevation.
- Mariner's wheel exercise active circular shoulder movement using a wall-mounted wheel apparatus to promote multi-planar active ROM and improve shoulder girdle coordination.

Dosage: The free-exercise programme was performed for 3 sets of 10 repetitions per exercise per session, combined with Wax therapy, 5 days a week for 4 weeks identical treatment frequency, duration and session structure to Group A, so that the only differing variable between groups was the specific exercise technique (Scapular PNF vs free exercises).

4. Statistical analysis

Data collected before and after the 4-week intervention were tabulated and analysed using descriptive and inferential statistics. Categorical variables (e.g., gender) were summarised as frequencies and percentages, and continuous variables (NPRS scores and ROM values) were summarised as mean ± standard deviation.

- Within-group comparison of pre-test and post-test scores for each group was performed using the paired 't' test.
- Between-group comparison of post-test improvement between Group A and Group B was performed using the unpaired (independent samples) 't' test.

The level of statistical significance was set at $p < 0.05$ for all comparisons.

4.1 Study Flow Summary

Table 7: Overview of the Study Procedure

Stage	Group A	Group B
Screening & consent	Inclusion/exclusion criteria applied; informed consent obtained	Same
Allocation	Convenience sampling, n = 25	Convenience sampling, n = 25
Pre-test	NPRS + Goniometer (Flexion, Abduction, External Rotation)	Same
Intervention	Wax therapy → Scapular PNF (D1 flexion pattern, Rhythmic Stabilization); 3 sets × 10 reps, 5 days/week × 4 weeks	Wax therapy → Codman's pendulum, finger ladder, mariner's wheel; 3 sets × 10 reps, 5 days/week × 4 weeks
Post-test	NPRS + Goniometer, repeated at week 4	Same
Analysis	Paired 't' test (within-group); Unpaired 't' test (between-group)	Same

4.2 Results

A total of 50 subjects with a clinical diagnosis of Periarthritis (Adhesive Capsulitis) of the shoulder, aged between 40 and 70 years, were enrolled and randomly allocated by convenience sampling into two equal groups of 25 subjects each. Group A received Scapular Proprioceptive Neuromuscular Facilitation (PNF) technique along with Wax therapy, and Group B received Shoulder free exercises along with Wax therapy. Both groups were treated for 3 sets of 10 repetitions, 5 days a week, for 4 weeks. Pain was assessed using the Numerical Pain Rating Scale (NPRS) and shoulder Range of Motion (ROM) flexion, abduction and external rotation was assessed using a Universal Goniometer, both before (pre-test) and after (post-test) the 4-week intervention. Data were analysed using paired 't' test (within-group, pre- vs post-test) and unpaired 't' test (between-group, Group A vs Group B), with the level of significance set at $p < 0.05$.

4.2.1 Demographic Profile

The mean age of subjects in Group A was 53.6 years, and in Group B was 50.4 years, indicating comparable age distribution between groups within the 40–70 year inclusion range. Group A comprised 13 male and 12 female subjects, while Group B comprised 9 male and 16 female subjects, consistent with the higher reported prevalence of Periarthritis shoulder among females in the middle-aged population.

4.2.2 Effect on Pain (NPRS)

Table 1 shows the pre- and post-test comparison of pain scores within each group, and the between-group comparison of post-test improvement.

Table 1: Comparison of NPRS Pain Scores (Pre-test vs Post-test) and Between-Group Improvement

Variable	Group A (Pre)	Group A (Post)	Group B (Pre)	Group B (Post)
NPRS Mean	7.96	3.12	7.68	4.56

Within Group A, the mean NPRS score reduced from 7.96 to 3.12 (mean difference = 4.84), and this reduction was statistically significant (paired t = 28.4542, p < 0.0001). Within Group B, the mean NPRS score reduced from 7.68 to 4.56 (mean difference = 3.12), which was also statistically significant (paired t = 16.0617, p < 0.0001). On comparing the post-test improvement between groups, the mean pain reduction was greater in Group A (post-test mean = 3.12) than in Group B (post-test mean = 4.56), and this between-group difference was statistically significant (unpaired t = 6.1589, p < 0.0001), indicating that Scapular PNF technique combined with Wax therapy produced significantly greater pain relief than Shoulder free exercises combined with Wax therapy.

4.2.3 Effect on Range of Motion Flexion

Table 2: Comparison of Shoulder Flexion ROM (Pre-test vs Post-test) and Between-Group Improvement

Variable	Group A (Pre)	Group A (Post)	Group B (Pre)	Group B (Post)
Flexion Mean (°)	85.8	125.2	93.8	116.0

Group A showed a mean improvement in flexion from 85.8° to 125.2° (mean difference = 39.4°; paired t = 7.8131, p < 0.0001). Group B improved from 93.8° to 116.0° (mean difference = 22.2°; paired t = 16.7497, p < 0.0001). Both improvements were statistically significant. On between-group comparison, Group A's post-test flexion (125.2°) was significantly greater than Group B's (116.0°), with an unpaired t value of 2.0218 (p = 0.0488), indicating a statistically significant, though modest, advantage of Scapular PNF technique with Wax therapy over Shoulder free exercises with Wax therapy for restoring flexion.

4.2.4 Effect on Range of Motion Abduction

Table 3: Comparison of Shoulder Abduction ROM (Pre-test vs Post-test) and Between-Group Improvement

Variable	Group A (Pre)	Group A (Post)	Group B (Pre)	Group B (Post)
Abduction Mean (°)	82.6	119.4	98.6	117.6

Group A improved in abduction from 82.6° to 119.4° (mean difference = 36.8°; paired t = 14.4453, p < 0.0001). Group B improved from 98.6° to 117.6° (mean difference = 19.0°; paired t = 19.8449, p < 0.0001). Both within-group improvements were highly significant. However, the between-group comparison of post-test abduction (Group A 119.4° vs Group B 117.6°) showed an unpaired t value of only 0.3420 (p = 0.7339), which is not statistically significant. This indicates that although Group B started from a higher pre-test abduction value, both interventions produced a comparable degree of improvement in abduction, with no significant advantage of one treatment over the other for this specific movement.

4.2.5 Effect on Range of Motion External Rotation

Table 4: Comparison of Shoulder External Rotation ROM (Pre-test vs Post-test) and Between-Group Improvement

Variable	Group A (Pre)	Group A (Post)	Group B (Pre)	Group B (Post)
External Rotation Mean (°)	20.0	46.4	20.6	34.4

Group A improved in external rotation from 20.0° to 46.4° (mean difference = 26.4°; paired t = 13.5548, p < 0.0001). Group B improved from 20.6° to 34.4° (mean difference = 13.8°; paired t = 11.5000, p < 0.0001). Both within-group changes were statistically significant. On between-group comparison, Group A's post-test external rotation (46.4°) was significantly greater than Group B's (34.4°), with an unpaired t value of 4.3615 (p < 0.0001) the

largest between-group effect recorded across all outcome variables, indicating that Scapular PNF technique with Wax therapy was distinctly more effective than Shoulder free exercises with Wax therapy in restoring external rotation.

4.2.6 Summary of Findings

Table 5: Summary of Between-Group (Unpaired 't') Comparisons

Outcome	Unpaired 't' value	p value	Significant?	Favoured Group
Pain (NPRS)	6.1589	< 0.0001	Yes	Group A
ROM – Flexion	2.0218	0.0488	Yes	Group A
ROM – Abduction	0.3420	0.7339	No	Neither (comparable)
ROM – External Rotation	4.3615	< 0.0001	Yes	Group A

Overall, both Group A (Scapular PNF technique with Wax therapy) and Group B (Shoulder free exercises with Wax therapy) produced statistically significant within-group improvement in pain and in all three planes of shoulder ROM after 4 weeks. When the two treatment approaches were compared directly, Group A demonstrated a significantly greater improvement in pain relief, flexion, and external rotation, while abduction improved to a comparable, statistically similar extent in both groups.

Discussion

The present study compared the effectiveness of Scapular Proprioceptive Neuromuscular Facilitation (PNF) technique combined with Wax therapy (Group A) against Shoulder free exercises combined with Wax therapy (Group B) on pain and range of motion in patients with Periarthritis shoulder. Both interventions produced statistically significant within-group improvement, but Group A demonstrated a significantly greater reduction in pain and greater gains in flexion and external rotation, with abduction improving comparably in both groups.

The magnitude and pattern of improvement observed in this study are consistent with the biomechanical model of scapular involvement in frozen shoulder described by Fayad et al. [11], who reported that scapulohumeral rhythm in the affected shoulder is inversely related to the severity of restriction in glenohumeral range of motion, with an exaggerated scapular contribution compensating for capsular tightness at the glenohumeral joint. This compensatory pattern is most marked in the early arc of elevation, which corresponds to the movement range where our subjects showed the greatest baseline deficits, particularly in external rotation.

This is consistent with the classical description of scapulohumeral rhythm by Dvir and Berme [12], who reported that the glenohumeral-to-scapulothoracic contribution to arm elevation approximates a 2:1 ratio in the normal shoulder, a ratio that becomes disturbed once the glenohumeral capsule loses extensibility, as occurs in Periarthritis. Restoring the normal contribution of the scapulothoracic joint which is precisely what the diagonal, rotational Scapular PNF patterns used in Group A were designed to do would therefore be expected to have a more direct effect on restoring true glenohumeral motion than free exercises that do not specifically target scapular mobility, which may explain the superior flexion and external-rotation outcomes seen in Group A of the present study.

The greater improvement in external rotation seen in Group A is further supported by Kibler and McMullen [13], who described scapular dyskinesis as a common and clinically important contributor to shoulder pain and dysfunction, and by Lin et al. [14], who documented an imbalance between the upper and lower trapezius in patients with frozen shoulder syndrome, favouring upper-trapezius dominance and scapular elevation. The Rhythmic Stabilization pattern of Scapular PNF used in Group A specifically facilitates the lower trapezius, rhomboids, and serratus anterior through resisted scapular elevation, abduction, and upward rotation, which would be expected to correct this imbalance more effectively than the largely humerothoracic movements

comprising the free-exercise programme (Codman's pendulum, finger ladder, and mariner's wheel exercises) used in Group B.

The mechanism underlying the greater ROM gains with the PNF technique is consistent with the neurophysiological basis of PNF discussed earlier [6]. González-Ravéet al. [15] reported a statistically significant improvement in shoulder ROM following a structured PNF stretching programme compared with a non-stretching control group in older adults, attributing the gain to autogenic inhibition of the target muscle group through Golgi tendon organ stimulation during the hold-relax component of PNF, which reduces reflexive muscle guarding and permits greater elongation of periarticular soft tissue. A comparable mechanism is likely to explain the significantly greater pain relief and ROM gains observed with Scapular PNF in Group A of the present study, since the hold-relax/rhythmic-stabilization component used at the scapulothoracic joint would be expected to reduce guarding in the peri-scapular musculature that commonly accompanies painful glenohumeral restriction.

This finding is also in agreement with Comuk Balci et al. [7], who reported that the scapular PNF group achieved significantly greater improvement in pain and shoulder ROM than the classic exercise group, and with Jothiprasanna and Rajeswari [8], who similarly concluded that scapular PNF technique was effective in improving functional range of motion in adhesive capsulitis of the shoulder. Both studies support the trend seen in the present study, where the group receiving scapular-specific PNF outperformed the group receiving a general free-exercise programme.

Similarly, Eapen et al. [10] found that scapular stabilization exercises produced significant improvement in scapular dyskinesis, shoulder ROM, pain, and functional status in subjects with adhesive capsulitis, reinforcing the rationale for targeting the scapulothoracic joint rather than the glenohumeral joint alone in the rehabilitation of Periarthritis shoulder, a rationale that is directly reflected in the superior outcomes of Group A in the present study.

The addition of Wax therapy to both groups is supported by Viswanath Reddy et al. [4], who reported that paraffin wax therapy combined with manual mobilization produced significant improvement in pain, ROM, and functional status of the shoulder in diabetic subjects with adhesive capsulitis, and by Muddassir Riaz et al. [9], who found paraffin wax bath therapy to be more effective than therapeutic ultrasound in improving soft-tissue extensibility around stiff joints. The superficial heat delivered by paraffin wax increases collagen extensibility and local blood flow and reduces pain and muscle spasm, which would explain the statistically significant within-group improvement seen in both Group A and Group B of the present study, since both groups received Wax therapy as a common adjunct prior to their respective exercise protocols.

The comparable improvement in abduction between the two groups (unpaired $t = 0.3420$, $p = 0.7339$) is a notable finding of this study. This may be explained by the fact that abduction, unlike external rotation, is influenced substantially by generalized deltoid and rotator-cuff activity in addition to scapular stabilization, and both the free-exercise programme (mariner's wheel, pendular exercise) and the PNF programme incorporated broad multi-planar movement of the arm; Wax therapy administered to both groups equally may also have contributed a common therapeutic ceiling for this particular movement. This is consistent with Nellutlaet al. [16], who reported that PNF movement patterns were as efficacious as rather than clearly superior to conventional free exercises for improving functional shoulder activity in chronic Periarthritis, indicating that not every outcome measure necessarily favours PNF over conventional exercise, and that the relative advantage of PNF may be movement-plane-specific rather than global.

Finally, the overall pattern of results significant within-group improvement in both groups with a between-group advantage favouring Scapular PNF for pain, flexion, and external rotation parallels Maickiet al. [17], who reported that PNF-based treatment was more effective than manual therapy alone in both the short and long term for a related musculoskeletal condition of the cervical spine, supporting the broader clinical principle that PNF techniques applied to a proximal, functionally linked joint (the scapulothoracic joint, in this case) can produce measurable secondary benefit at the primarily affected joint (the glenohumeral joint). This is further consistent

with Oatis [18], who noted that the action of the rotator-cuff (SITS) muscles in shoulder elevation depends indirectly on adequate scapular stabilization, since all four muscles originate from the scapula; where scapulothoracic stabilization is restored, more efficient rotator-cuff action, and therefore more efficient glenohumeral motion, is expected to follow which is consistent with the pattern of greater flexion and external-rotation gains observed in the scapular PNF group of the present study.

Taken together, these findings support the hypothesis that correcting scapulothoracic mechanics through Scapular PNF, in addition to the pain-relieving and tissue-extensibility benefits of Wax therapy, provides a more complete rehabilitation strategy for Periarthritis shoulder than free exercises with Wax therapy alone particularly for pain relief and for restoring flexion and external rotation, which are the movements most dependent on normal scapulohumeral rhythm.

Conclusion

This study concludes that both the Scapular PNF technique with Wax therapy (Group A) and Shoulder free exercises with Wax therapy (Group B) are effective in reducing pain and improving glenohumeral range of motion in patients with Periarthritis shoulder over a 4-week period.

However, when the two approaches were compared, the Scapular PNF technique combined with Wax therapy produced significantly greater improvement in pain relief and in shoulder flexion and external rotation than Shoulder free exercises with Wax therapy, while improvement in abduction was comparable between the two groups. This suggests that Scapular PNF technique exerts its added benefit primarily by restoring normal scapulohumeral rhythm and reducing peri-scapular muscle guarding, rather than through a uniform effect across all planes of shoulder movement.

It is therefore concluded that a 4-week intervention of Scapular PNF technique in addition to Wax therapy is an effective and clinically valuable approach for decreasing pain and increasing range of motion by restoring scapulohumeral rhythm in patients with Periarthritis shoulder, and may be considered as a useful adjunct alongside conventional free exercises in the physiotherapy management of this condition.

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