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Proprioceptive Neuromuscular Facilitation for Shoulder Pain: An Updated Systematic Review and Evidence Synthesis of Controlled Trials on Pain, Disability, and Range of Motion

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ABSTRACT:

Background: Shoulder pain is a common musculoskeletal problem for which exercise-based rehabilitation is frequently prescribed. Proprioceptive neuromuscular facilitation (PNF) is used to address pain, range of motion, neuromuscular control, and shoulder function, but trials differ substantially in diagnosis, technique, comparator, and outcome

measurement.

Objective: To update the evidence on the effects of PNF-based rehabilitation on pain, shoulder-related disability, and range of motion in adults with symptomatic shoulder disorders.

Methods: PubMed-indexed literature, PEDro records, clinical-trial information, publisher pages, and prior systematic reviews were searched and cross-checked through 2 October 2026. Randomized or controlled clinical studies evaluating PNF as a shoulder rehabilitation intervention were considered. Because the published literature contains clinically heterogeneous populations and several reports do not provide sufficient numerical data for independent effect-size calculation, quantitative findings that could be verified were synthesized separately from narrative evidence rather than manufacturing a new pooled estimate.

Results: A 2025 meta-analysis identified nine English-language studies involving 158 participants receiving PNF and reported a pooled VAS improvement of -3.26 (95% CI -4.33 to -2.20), while the pooled SPADI estimate was not statistically significant (-20.57 , 95% CI -47.92 to 6.78). A separate 2025 review of scapulohumeral periarthritis identified 12 randomized trials involving 885 participants and reported improvements in pain, shoulder function, and activities of daily living, but substantial heterogeneity and methodological concerns were present. Newer evidence includes an 80-participant assessor-blinded adhesive-capsulitis trial, a 2026 56-participant trial examining neural mobilization added to PNF, a 2026 chronic subacromial-bursitis trial after corticosteroid injection, and a 2025 rotator-cuff-syndrome trial.

Conclusion: PNF is associated with improvements in several shoulder outcomes in the existing evidence base, but the certainty of a generalizable treatment effect is limited by diagnostic heterogeneity, small samples, short follow-up in many trials, co-interventions, and inconsistent reporting. A publication-quality updated meta-analysis should use the complete database exports and full texts to independently extract all eligible studies before a new pooled effect is claimed

1. INTRODUCTION

1.1 Background

Shoulder pain encompasses a heterogeneous group of disorders affecting the glenohumeral joint, rotator cuff, subacromial structures, scapular system, and surrounding soft tissues. Common clinical presentations include adhesive capsulitis, subacromial pain or impingement, rotator-cuff-related shoulder pain, and myofascial pain. These conditions may be associated with pain, restricted movement, impaired shoulder function, and limitations in activities of daily living.

PNF is a rehabilitation approach based on diagonal and spiral movement patterns, resisted muscle activation, stretching, and proprioceptive input. Shoulder PNF protocols reported in the literature include upper-extremity D2 patterns, scapular anterior elevation/posterior depression, posterior elevation/anterior depression, hold-relax techniques, rhythmic stabilization, and combinations with conventional physiotherapy.

The supplied review record originally proposed a systematic review of PNF for chronic neck pain, with pain, disability, and range of motion as principal outcomes and randomized trials as the target design. The present manuscript adapts the clinical question to shoulder pain while updating the evidence base. The original record specified PubMed and Scopus, no language or date restrictions, independent screening and extraction, and Cochrane RoB 2 assessment.

Importantly, the shoulder question has already been addressed by systematic reviews. A 2025 Journal of Orthopaedic Reports meta-analysis searched MEDLINE and Embase to April 2024 and included nine studies involving 158 participants. A separate 2025 BMC Musculoskeletal Disorders review searched ten databases to January 2024 and included 12 randomized trials

involving 885 participants with scapulohumeral periarthritis. These reviews make an updated approach necessary rather than presenting the question as entirely unexplored.

1.2 Rationale

The existing reviews differ substantially in scope. The 2025 Journal of Orthopaedic Reports review included symptomatic shoulder conditions but only nine studies and 158 participants, whereas the BMC review focused on scapulohumeral periarthritis and included a larger set of predominantly Chinese trials. Since both searches predated several 2025–2026 trials, an updated review can add clinically important evidence, especially for adhesive capsulitis, rotator-cuff syndrome, and chronic subacromial bursitis.

The central methodological challenge is clinical heterogeneity. PNF is not a single standardized intervention, and the underlying diagnoses are not interchangeable. Therefore, an updated review should prioritize diagnosis-specific synthesis and avoid combining all shoulder disorders into one pooled effect unless there is a defensible clinical and statistical rationale.

1.3 Objective

To systematically identify and synthesize randomized or controlled evidence evaluating PNF-based rehabilitation for shoulder pain and associated functional or mobility outcomes, with particular attention to pain intensity, shoulder disability/function, and range of motion.

2. METHODS

2.1 Reporting framework

The manuscript is structured in accordance with PRISMA 2020 principles. PRISMA 2020 recommends transparent reporting of information sources, the dates each source was searched, complete search strategies, study-selection procedures, data items, synthesis methods, and risk-of-bias assessment.

2.2 Eligibility criteria

Domain	Eligibility
Population	Adults with symptomatic shoulder conditions, including adhesive capsulitis/frozen shoulder, subacromial impingement or pain, rotator-cuff syndrome, and selected shoulder-region myofascial pain studies.
Intervention	PNF used as a therapeutic intervention, alone or added to conventional rehabilitation.
Comparator	Conventional physiotherapy, therapeutic exercise, stretching, mobilization/manual therapy, usual care, or another active rehabilitation intervention.
Outcomes	Pain intensity, shoulder disability/function, shoulder ROM, and relevant shoulder biomechanical or quality-of-life outcomes.
Design	Randomized controlled trials and controlled clinical trials. Non-randomized evidence is considered separately and not treated as equivalent to RCT evidence.
Language/date	No conceptual language or publication-date restriction; practical inclusion depends on retrievable full text and sufficient information for verification.

2.3 Information sources

The updated search was cross-checked using PubMed/PMC, PEDro, publisher-indexed records, ClinicalTrials.gov-linked

information where available, and prior systematic reviews. The original registration record specified PubMed and Scopus. In this environment, direct subscription-level Scopus and Embase result exports were not available; therefore, this manuscript does not invent Scopus/Embase hit counts. Their database-specific strategies are supplied below so the search can be reproduced by the research team with institutional access.

2.4 Search strategy

Core concept: (proprioceptive neuromuscular facilitation OR PNF OR PNF stretching OR hold-relax OR contract-relax OR rhythmic stabilization OR diagonal pattern*) AND (shoulder pain OR shoulder disorder* OR adhesive capsulitis OR frozen shoulder OR subacromial pain OR shoulder impingement OR rotator cuff OR scapulohumeral periarthritis OR myofascial shoulder pain).

PubMed draft strategy:

("Proprioceptive Neuromuscular Facilitation"[Mesh] OR "proprioceptive neuromuscular facilitation"[tiab] OR PNF[tiab] OR "hold relax"[tiab] OR "contract relax"[tiab] OR "rhythmic stabilization"[tiab] OR "diagonal pattern*" [tiab]) AND ("Shoulder Pain"[Mesh] OR "shoulder pain"[tiab] OR "shoulder disorder*" [tiab] OR "adhesive capsulitis"[tiab] OR "frozen shoulder"[tiab] OR "subacromial pain"[tiab] OR "shoulder impingement"[tiab] OR "rotator cuff"[tiab] OR "scapulohumeral periarthritis"[tiab] OR "myofascial pain"[tiab])

Scopus draft strategy:

((("proprioceptive neuromuscular facilitation" OR PNF OR "hold relax" OR "contract relax" OR "rhythmic stabilization" OR "diagonal pattern*")) AND ("shoulder pain" OR "shoulder disorder*" OR "adhesive capsulitis" OR "frozen shoulder" OR "subacromial pain" OR "shoulder impingement" OR "rotator cuff" OR "scapulohumeral periarthritis" OR "myofascial pain"))

Embase draft strategy:

("proprioceptive neuromuscular facilitation"/exp OR "proprioceptive neuromuscular facilitation":ti,ab OR PNF:ti,ab OR "hold relax":ti,ab OR "contract relax":ti,ab OR "rhythmic stabilization":ti,ab) AND ("shoulder pain"/exp OR "shoulder pain":ti,ab OR "adhesive capsulitis":ti,ab OR "frozen shoulder":ti,ab OR "subacromial pain":ti,ab OR "shoulder impingement":ti,ab OR "rotator cuff":ti,ab)

PEDro and supplementary searching used combinations of PNF, proprioceptive neuromuscular facilitation, shoulder, adhesive capsulitis, impingement, and rotator cuff. Citation chasing was performed from relevant systematic reviews and primary trials.

2.5 Study selection and data extraction

Potentially relevant records should be deduplicated and screened independently by two reviewers. Full-text eligibility should be assessed against the prespecified criteria. Extracted fields should include study design, sample size, diagnosis, symptom duration, PNF technique, frequency and duration, comparator, co-interventions, outcome instrument, assessment time point, and numerical data required for effect-size calculation.

The present evidence synthesis reports only numerical values that were directly verifiable from accessible primary reports or published systematic-review tables. Missing standard deviations, medians reported without dispersion suitable for conversion, or inaccessible numerical tables were not reconstructed by assumption.

2.6 Risk of bias

RoB 2 is the preferred framework for randomized trials. It assesses bias arising from the randomization process, deviations from intended interventions, missing outcome data, outcome measurement, and selection of the reported result. Judgements are low risk, some concerns, or high risk.

2.7 Synthesis plan

A new pooled estimate should only be calculated after complete extraction of eligible studies. Where the same construct is measured with different validated instruments, standardized mean difference with 95% confidence intervals is appropriate; where the same scale is used, mean difference is preferable. A random-effects model is appropriate when clinical or methodological heterogeneity is expected. I^2 should be interpreted alongside clinical and methodological heterogeneity rather than used as a stand-alone decision rule.

Because the available studies span distinct diagnoses and interventions, the preferred synthesis hierarchy is: (1) adhesive capsulitis/frozen shoulder; (2) subacromial/rotator-cuff-related disorders; (3) myofascial/upper-trapezius pain; and (4) other shoulder conditions. Acute one-session effects and postoperative/oncology populations should not be automatically pooled with chronic primary shoulder disorders.

3. RESULTS

3.1 Evidence identified

The updated search identified a substantial pre-existing evidence base rather than an empty field. A 2025 meta-analysis of symptomatic shoulder conditions reported nine included studies and 158 participants receiving PNF. A separate 2025 meta-analysis of scapulohumeral periarthrititis identified 478 records and ultimately included 12 randomized trials involving 885 participants. The latter review included eight Chinese-language and four English-language reports.

Additional eligible or potentially eligible studies published after those review cutoffs were identified in 2025–2026. These include an assessor-blinded randomized trial of 80 adults with adhesive capsulitis, a 2026 randomized trial of 56 adults comparing neural mobilization plus PNF versus PNF plus conventional physiotherapy, and a 2026 randomized pilot trial of PNF versus standardized exercise-based physiotherapy following ultrasound-guided corticosteroid injection in chronic shoulder pain associated with subacromial bursitis. A 2025 randomized trial in rotator-cuff syndrome was also identified.

3.2 Characteristics of the established evidence

Study/review	Population	Sample	Intervention/comparator	Main outcomes
Godges et al., 2003	Shoulder musculoskeletal disorders	20 total in the cited meta-analysis table	Soft-tissue mobilization + PNF vs comparator	Glenohumeral external rotation and overhead reach
Citaker et al., 2005	Shoulder impingement syndrome	40	Mobilization vs PNF	VAS, ROM, UCLA criteria
Akbaş et al., 2015	Adhesive capsulitis	36	Upper-extremity/scapular PNF + conventional therapy vs conventional therapy	VAS, SPADI, ROM
Balci et al., 2016	Stage-II adhesive capsulitis	53	Scapular PNF + modalities vs exercise + modalities vs modalities	VAS, ROM, scapular measures
Lin et al., 2022	Frozen shoulder	48 randomized	PNF joint mobilization vs traditional manual therapy	VAS, ROM, MRI structural measures
İğrek & Kuru Çolak, 2022	Subacromial impingement syndrome	44	Conventional therapy + PNF vs conventional therapy + mobilization vs control	Pain, ROM, function, strength
Khan et al., 2025	Adhesive capsulitis	80	Upper-extremity/scapular PNF vs capsular stretching	NPRS, ROM, SPADI
de Sire et al., 2026	Chronic shoulder pain/subacromial bursitis	Randomized pilot study	PNF vs standardized exercise after common corticosteroid-injection protocol	NRS, DASH, EQ-5D, ROM
Hegazy et al., 2026	Adhesive capsulitis	56	Median-nerve neural mobilization + PNF + conventional PT vs PNF + conventional PT	VAS, SPADI, passive ROM
Rotator-cuff syndrome RCT, 2025	Rotator cuff syndrome	60 enrolled	PNF + conservative care vs MWM + conservative care vs conservative care	VAS, ROM, proprioception, scapular dyskinesis, WORC, SF-36

3.3 Findings from the 2025 meta-analysis of symptomatic shoulder conditions

The 2025 Journal of Orthopaedic Reports meta-analysis searched MEDLINE and Embase on 29 April 2024 and manually

screened references. Nine studies involving 158 participants were included. Six studies involving 120 participants contributed VAS data. The pooled VAS improvement was -3.26 (95% CI -4.33 to -2.20 ; $p < 0.01$). The pooled SPADI estimate was -20.57 (95% CI -47.92 to 6.78 ; $p = 0.14$). Abduction, external rotation, internal rotation, and flexion were reported to improve in the quantitative synthesis.

The review reported a mean treatment/follow-up duration of approximately 3.25 ± 1.20 weeks. Its included studies came mainly from Turkey and India, with one from the United States. The authors emphasized clinical heterogeneity and variability in methodology.

3.4 Findings from the 2025 scapulohumeral-periarthritis meta-analysis

The 2025 BMC Musculoskeletal Disorders review searched ten databases and identified 478 records, with 12 randomized trials and 885 participants included. Ten studies reported pain outcomes. The VAS subgroup showed SMD -0.67 (95% CI -1.18 to -0.15 ; $p = 0.03$; $I^2 = 67\%$), while a Japanese Orthopaedic Association pain-score subgroup showed SMD 0.79 (95% CI 0.23 to 1.35 ; $p < 0.01$; $I^2 = 89\%$). Nine studies reported joint function; after sensitivity analyses excluding two studies, the review reported SMD 1.13 (95% CI 0.96 to 1.31). Five studies reported activities of daily living, with SMD 1.06 (95% CI 0.77 to 1.34 ; $I^2 = 57\%$).

The same review judged only two of its 12 trials to have low overall risk of bias; most had some concerns. The authors also noted small samples, concentration of studies in China, limited reporting of blinding, and limited safety reporting.

3.5 Newer primary evidence

Khan et al. (2025) conducted an assessor-blinded randomized trial in 80 adults with adhesive capsulitis, 40 per group. The PNF group received upper-extremity D2 flexion with hold-relax plus scapular PNF for six weeks; the control group received conventional physiotherapy including capsular stretching and modalities. The authors reported significant between-group differences favoring PNF for pain and SPADI outcomes and significant differences in lateral and medial rotation, although abduction was not significantly different. The study used intention-to-treat analysis.

Lin et al. (2022) randomized 48 people with frozen shoulder to PNF joint mobilization or traditional manual therapy. At mid-term assessment, PNF produced significantly better VAS and ROM outcomes; MRI measures of coracohumeral-ligament and axillary-recess capsule thickness also favored PNF. Final ROM differences were directionally favorable but not statistically significant for all measures.

Hegazy et al. (2026) randomized 56 adults with adhesive capsulitis to median-nerve slider neural mobilization added to PNF and conventional physiotherapy versus PNF and conventional physiotherapy. Adjusted between-group differences favored the combined intervention for VAS (-0.88 , 95% CI -1.24 to -0.52), SPADI (-5.69 , 95% CI -9.83 to -1.55), abduction (14.08° , 95% CI 11.22 to 16.94), external rotation (6.71° , 95% CI 5.26 to 8.16), and internal rotation (1.83° , 95% CI 0.94 to 2.72). The authors noted that only the abduction result approached the cited minimal clinically important difference; pain and disability differences did not reach their respective MCID thresholds.

de Sire et al. (2026) evaluated adults with chronic shoulder pain associated with subacromial bursitis following a common ultrasound-guided corticosteroid-injection protocol. Participants then received PNF or standardized exercise-based physiotherapy. DASH scores favored PNF at 4 and 12 weeks after physiotherapy, but not at 24 weeks. For example, DASH at the first post-physiotherapy assessment was 14.75 ± 13.09 in the PNF group versus 26.43 ± 16.63 in the conventional group ($p = 0.004$), while the between-group difference was no longer significant at the later 24-week assessment. These findings are difficult to attribute to PNF alone because both groups first received the same injection protocol.

A 2025 randomized controlled study in rotator-cuff syndrome enrolled 60 participants and compared PNF plus conservative treatment with Mulligan movement-with-mobilization plus conservative treatment and conservative treatment alone. Outcomes included pain, ROM, proprioception, scapular dyskinesis, the Western Ontario Rotator Cuff Index, and SF-36. The published report found that the three interventions produced positive effects across outcomes, while the mobilization-with-movement group showed statistically superior effects for selected pain, proprioception, and functionality outcomes. This study therefore does not establish PNF superiority.

4. DISCUSSION

4.1 Principal interpretation

Across the available literature, PNF is consistently associated with improvement from baseline in pain, ROM, or function in

several shoulder populations. The more difficult question is whether PNF provides an incremental benefit over established physiotherapy approaches. Evidence for incremental benefit is more variable. Some adhesive-capsulitis trials report superior pain, disability, or ROM outcomes with PNF, whereas other studies report similar improvement between PNF and comparator interventions.

The two existing 2025 reviews illustrate why a single pooled effect across all shoulder disorders can be misleading. The 2025 symptomatic-shoulder review found a large pooled VAS improvement but no statistically significant pooled SPADI difference, while the 2025 scapulohumeral-periarthritis review found statistically significant pooled effects for pain, shoulder function, and activities of daily living but substantial heterogeneity. Differences in eligibility criteria, languages, included diagnoses, and study quality account for much of this divergence.

4.2 Adhesive capsulitis

Adhesive capsulitis is the shoulder population for which the evidence appears most coherent. Trials have examined scapular and upper-extremity PNF patterns, hold-relax techniques, and PNF joint mobilization. The 2015 trial found additional benefit for night pain and flexion/abduction ROM, the 2016 acute study found immediate within-group improvements but no clear between-group superiority, and the 2022 and 2025 trials provide further evidence of improvement with longer intervention periods.

Nevertheless, the studies differ in disease duration, stage, comparator therapy, treatment frequency, and outcome instruments. The 2025 trial enrolled participants with one to three months of shoulder pain, whereas other studies may have included longer-standing disease. Therefore, 'adhesive capsulitis' should not automatically be treated as a homogeneous chronic-pain population.

4.3 Subacromial and rotator-cuff-related disorders

Evidence for subacromial and rotator-cuff-related shoulder pain is smaller and more heterogeneous. The 2005 shoulder-impingement trial compared mobilization and PNF and found both approaches effective, with mobilization better tolerated. The 2022 subacromial-impingement trial compared conventional physiotherapy plus PNF, conventional physiotherapy plus shoulder mobilization, and conventional physiotherapy alone. More recent rotator-cuff-syndrome evidence likewise suggests improvement across treatment groups without clear PNF superiority.

The 2026 chronic subacromial-bursitis study is particularly important because the PNF and conventional-physiotherapy groups shared a preceding injection intervention. Its longer follow-up suggests that some functional differences may emerge early and attenuate over time. This trial should therefore be synthesized separately from trials in which PNF is the principal difference between groups.

4.4 Clinical heterogeneity and the PNF intervention

PNF protocols varied markedly. Techniques included D2 flexion, scapular patterns, hold-relax, rhythmic stabilization, and combined upper-extremity/scapular approaches. Frequency ranged from single-session experiments to programs delivered four or five times per week for several weeks. Some studies used PNF in addition to ultrasound, heat, exercise, or other conventional treatments.

This variation limits the interpretation of a single pooled 'PNF effect.' Future trials should report therapist training, exact PNF pattern, resistance, contraction duration, repetitions, session duration, treatment frequency, progression criteria, and adherence.

4.5 Safety and patient-centered outcomes

Adverse-event reporting is limited in the existing PNF literature. Functional outcomes and pain are much more commonly reported than adverse events, adherence, or long-term recurrence. This is a reporting gap rather than evidence that PNF has no adverse effects.

4.6 Strengths

Strengths of this updated evidence synthesis include incorporation of the major 2025 reviews, identification of newer 2025–2026 randomized evidence, cross-checking of primary trial reports and PEDro records, and explicit separation of distinct shoulder diagnoses. The manuscript also avoids converting inaccessible or incompletely reported data into invented numerical estimates.

4.7 Limitations

The principal limitation is that direct subscription-level exports from Scopus and Embase were not available in the present environment. Consequently, an exact independent PRISMA flow count across every database cannot be claimed. In addition, some older Chinese-language studies identified by the 2025 BMC review could not be independently verified at the full-text numerical-data level. The current manuscript therefore should not be represented as a completed de novo meta-analysis until the research team runs the supplied database strategies and independently extracts every eligible full text.

A second limitation is substantial clinical heterogeneity. Pooling adhesive capsulitis, impingement, rotator-cuff syndrome, myofascial pain, postoperative shoulder dysfunction, and chronic subacromial bursitis can produce a mathematically precise but clinically ambiguous estimate. Diagnosis-specific meta-analysis is preferable.

5. CONCLUSION

Current randomized evidence supports PNF as a potentially useful component of rehabilitation for several shoulder disorders, particularly adhesive capsulitis, with reported improvements in pain, shoulder function, and range of motion. However, evidence of superiority over conventional physiotherapy is inconsistent, and the clinical relevance of some statistically significant differences is uncertain. The literature is characterized by small samples, heterogeneous PNF protocols, varied comparators, short follow-up in many trials, and incomplete reporting of safety and adherence.

For a definitive updated meta-analysis suitable for journal submission, the next methodological step is to run the full PubMed, Scopus, Embase, PEDro, CENTRAL, and trial-registry searches using the strategies provided, deduplicate the exported records, screen every record, obtain all eligible full texts, and independently extract means, standard deviations, sample sizes, and follow-up time points. Only after that step should new pooled estimates and a final PRISMA flow diagram be generated.

6. Data extraction table for completion before submission

Study	N	Diagnosis	PNF protocol	Comparator	Pain	Disability/function	ROM	Follow-up	Numerical data independently verified?
Godges et al., 2003	20	Shoulder musculoskeletal disorder	STM + PNF	Comparator	—	—	ER/overhead reach	Immediate	Partly
Citaker et al., 2005	40	Shoulder impingement	PNF	Mobilization	VAS	UCLA	ROM	Post-treatment	Partly
Akbaş et al., 2015	36	Adhesive capsulitis	UE + scapular PNF	Conventional PT	VAS	SPADI	Flex/abd/IR/ER	3 weeks	Partly
Bacı et al., 2016	53	Stage-II adhesive capsulitis	Scapular PNF	Exercise/control	VAS	—	Flex/abd	Immediate	Yes for reported tables
Lin et al., 2022	48	Frozen shoulder	PNF joint mobilization	Manual therapy	VAS	—	Passive ROM	4 weeks	Yes for reported comparisons
İğrek et al., 2022	44	Subacromial impingement	PNF + conventional PT	Mobilization + PT / control	VAS	Function	ROM/strength	4 weeks	Partly
Khan et al., 2025	80	Adhesive capsulitis	UE/scapular PNF	Capsular stretching + modalities	NPRS	SPADI	Abd/IR/ER	6 weeks	Median/IQR reported
Rotator-cuff syndrome RCT, 2025	60	Rotator cuff syndrome	PNF + conservative care	MWM + conservative / control	VAS	WORC	ROM	20 sessions	Partly
de Sire et al., 2026	—	Chronic subacromial bursitis	PNF after injection	Exercise after injection	NRS	DASH/EQ-5D	ROM	2–24 weeks	Yes for DASH; further extraction needed
Hegazy et al., 2026	56	Adhesive capsulitis	PNF + conventional PT	NMT + PNF + conventional PT	VAS	SPADI	Abd/ER/IR	6 weeks	Yes for adjusted effects

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