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Effect of Proprioceptive Neuromuscular Facilitation Stretching on Pain, Range of Motion and Function in Participants with Post-Immobilization Hip Stiffness: An Experimental Study

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ABSTRACT

Introduction: After a fracture, scar tissue and adhesions can form inside and around joints, causing stiffness. Restoring joint flexibility and rebuilding strength in the affected muscles is essential. Many people experience hip stiffness following a period of immobilization, which limits mobility and daily function. This study examines whether Proprioceptive Neuromuscular Facilitation (PNF) stretching can reduce pain and improve range of motion and functional ability in individuals with hip stiffness.

Objectives: To evaluate the difference between the effect of proprioceptive neuromuscular facilitation (PNF) stretching along with conventional physical therapy and conventional physical therapy alone on pain, range of motion and function in participants with post immobilization hip stiffness.

Material & method: A 4-week intervention study, 30 patients following post-immobilization hip stiffness were enrolled. They were divided into two groups by convenience sampling, Group A: (n=15):PNF (hold relax) stretching along with conventional physical therapy. Group B: (n=15) conventional physical therapy. Treatment consisted of 5 sessions/week for 4 weeks. Data was collected and analyzed using SPSS 26.

Result: In a 4-week study, Group A received PNF along with conventional physical therapy, exhibiting significant pain reduction (p=0.000), increased hip range of motion (p=0.004), and improved function (p=0.000). Group B, received conventional physical therapy, also experienced improvements. Intergroup analysis favored Group A, indicating its superior effects on pain, hip ROM, and function as compared to Group B.

Conclusion: Proprioceptive neuromuscular facilitation stretching along with conventional physical therapy is more effective in reducing pain, improving range of motion & function in participants with post-immobilization hip stiffness than conventional physical therapy alone.

Key words: Post-immobilization hip stiffness, Proprioceptive Neuromuscular Facilitation stretching, pain, range of motion, LEFS

INTRODUCTION

The hip joint is a multiaxial synovial ball-and-socket joint that provides stability while permitting movement in three planes,

including flexion-extension, abduction-adduction, and internal-external rotation. It plays a fundamental role in weight bearing, postural control, and locomotion, enabling activities such as walking, stair climbing, running, and sitting. Consequently, any restriction in hip mobility can substantially impair functional independence and quality of life. [1]

Hip fractures and other traumatic or operative conditions frequently require a period of immobilization to facilitate healing. However, prolonged immobilization often results in post-immobilization hip stiffness, characterized by pain, reduced range of motion (ROM), muscle weakness, and impaired functional performance. Hip fractures remain a major public health concern because they are associated with increased mortality, prolonged disability, reduced mobility, and loss of independence, particularly among older adults. [2]

The development of post-immobilization stiffness is attributed to several structural and physiological changes occurring within periarticular soft tissues. Immobilization causes abnormal collagen remodeling, increased collagen cross-linking, reduced glycosaminoglycan content, decreased tissue hydration, and adhesion formation within and around the joint. These alterations decrease tissue extensibility, restrict joint motion, and contribute to pain and functional limitation. Therefore, restoration of joint mobility and muscle flexibility is a primary objective of rehabilitation following hip trauma or surgery. [3]

Conventional physiotherapy remains the standard approach for managing post-immobilization hip stiffness and generally includes pain management, active and active-assisted ROM exercises, progressive muscle strengthening, balance training, gait training, and functional exercises. Although these interventions improve mobility and function, many individuals continue to experience residual stiffness and restricted ROM, indicating the need for adjunctive therapeutic interventions. [4]

Proprioceptive Neuromuscular Facilitation (PNF) stretching is an established therapeutic technique designed to improve muscle flexibility and joint mobility through alternating isometric muscle contractions and passive stretching. Among the different PNF techniques, the hold-relax method has been widely adopted because it is simple, comfortable for patients, and effective in increasing ROM. The physiological mechanisms underlying PNF include autogenic inhibition mediated through Golgi tendon organ stimulation, reduced muscle tone, enhanced neuromuscular control, and improved muscle extensibility. These mechanisms collectively facilitate greater joint mobility and functional recovery.[5]

Several clinical studies have demonstrated the effectiveness of PNF stretching in improving ROM, reducing pain, and enhancing functional outcomes across various musculoskeletal disorders. PNF stretching has shown beneficial effects in patients with chronic low back pain, total knee arthroplasty, post-traumatic elbow stiffness, and hamstring tightness. However, evidence regarding its effectiveness in patients with post-immobilization hip stiffness remains scarce and inconclusive. Some investigations have reported outcomes comparable to static stretching, whereas others have demonstrated superior improvements with PNF interventions. [6–9]

Despite growing evidence supporting PNF stretching in musculoskeletal rehabilitation, limited studies have specifically investigated the effectiveness of the hold-relax technique in individuals with post-traumatic or postoperative hip stiffness following prolonged immobilization. This represents an important gap in the literature because persistent hip stiffness continues to compromise pain, mobility, and functional independence despite conventional rehabilitation.

Therefore, the present study aimed to evaluate the effect of hold-relax Proprioceptive Neuromuscular Facilitation

stretching combined with conventional physical therapy on pain intensity, hip range of motion, and functional outcomes in individuals with post-immobilization hip stiffness. It was hypothesized that the addition of hold-relax PNF stretching would result in greater improvements in pain reduction, hip mobility, and lower extremity function than conventional physical therapy alone.

MATERIAL AND METHODOLOGY

- Ethical approval: Ethical approval was obtained from Institutional Ethical Committee
- Study design: An Experimental study.
- Study setting: Institutional Musculoskeletal physiotherapy department (O.P.D.) Sample selection: According to inclusion and exclusion criteria.
- Sample design: Convenience sampling
- Study duration: 1 year
- Treatment duration: 5 sessions/week for 4 weeks
- Sample size: 30
  - Group - A: 15
  - Group - B: 15

INCLUSION CRITERIA:

- Participants with hip stiffness post trauma or operation (Fractures of the proximal femur such as fracture head femur, fracture neck femur, fracture subtrochanteric and intertrochanteric femur, hip dislocations, total hip arthroplasty & hemiarthroplasty)
- Minimum 8 weeks old case of hip trauma/ surgery
- Age: 20 – 70 years
- Both males and females
- Unilateral involvement
- Willingness to participate in the study

EXCLUSION CRITERIA:

- Pathological fractures, lower limb Polytrauma (knee & ankle injuries), shaft femur fractures
- Other hip joint pathology such as Primary hip osteoarthritis, avascular necrosis, osteomyelitis
- Revision surgery
- Sacroiliac dysfunction
- Hip joint hypermobility syndrome
- Severe cognitive impairment
- Neurological & vascular conditions affecting lower limb

MATERIALS:

- Consent form
- Assessment form
- Plinth
- Pillow
- Chair
- Pen/pencil/paper eraser
- Weight cuff
- Stop watch
- Lower extremity functional scale
- NPRS scoring sheet
- Universal goniometer

OUTCOME MEASURES:

Outcome assessment was performed at baseline and after completion of the 4-week intervention using validated clinical outcome measures to evaluate pain intensity, hip range of motion (ROM), and lower extremity function.

Pain Intensity

Pain intensity was assessed using the Numerical Pain Rating Scale (NPRS). The NPRS is an 11-point self-reported scale ranging from 0 (no pain) to 10 (worst imaginable pain). It is a reliable, valid, and responsive instrument for measuring pain intensity in patients with musculoskeletal disorders and has demonstrated excellent test–retest reliability and sensitivity to clinical change. The minimal clinically important difference (MCID) for the NPRS is approximately 2 points in individuals with musculoskeletal pain.[10-11]

Hip Range of Motion

Active hip range of motion was measured using a universal goniometer. Hip flexion,

abduction, internal rotation, and external rotation were assessed according to standardized measurement procedures described by the American Academy of Orthopaedic Surgeons. Universal goniometry is considered a reliable and valid method for assessing joint mobility when standardized positioning and measurement techniques are followed.[12-14]

Functional Outcome

Functional status was evaluated using the Lower Extremity Functional Scale (LEFS). The LEFS is a patient-reported outcome measure consisting of 20 items that assess the ability to perform everyday functional activities involving the lower extremities. Each item is scored on a 5-point Likert scale (0–4), yielding a total score ranging from 0 to 80, with higher scores indicating better functional ability. The LEFS has demonstrated excellent reliability, validity, and responsiveness in patients with lower extremity musculoskeletal conditions and fractures. The minimal clinically important difference for the LEFS is 9 points.[15,16]

PROCEDURE

Participants were selected by convenience sampling. A total 30 participants were randomly assigned into two groups A and B. Participants who found suitable were asked to sign consent form. 15 participants allocated in Group A received PNF stretching along with conventional physical therapy, another 15 participants allocated in Group B received conventional physical therapy alone. All 30 participants completed the interventional physical therapy without dropout and analyzed. No loss to follow up was recorded during the data collection or analysis phase.

GROUP A -TREATMENT PROTOCOL FOR HOLD RELAX PNF:

Participants will be positioned comfortably in a lying position, and the physical therapist will move the hip joint to the end of the passive range of motion according to the direction of limitation in the hip joint. The physical therapist will ask the participant for a maximal isometric contraction of the target muscle for 10 sec. Following the maximal isometric contraction, the participant will be instructed to relax for 5 sec. The hip joint will be repositioned passively to the new limit of the range of motion and then physical therapist will apply a stretching force for an additional 10 sec. This procedure is repeated 10 times with a rest period of 10 sec between successive stretching. The treatment will be given 5 times per week for 4 weeks.[3,7]

PHOTOGRAPH: HOLD RELAX FOR HAMSTRINGS & HOLD RELAX FOR ADDUCTORS


PHOTOGRAPH: HOLD RELAX FOR EXTERNAL ROTATORS & HOLD RELAX FOR INTERNAL ROTATORS

GROUP B: CONVENTIONAL TREATMENT

HIP MUSCLE SETTING EXERCISE

Gluteal setting exercises: (10 repetitions× 1set/day)

10 repetitions of gluteal setting exercises were performed by the subjects in supine position. Subjects were instructed to "squeeze" (contract) the buttocks to increase awareness of the contracting muscles in a pinching manner and hold the isometric contraction for 10 seconds" A rest time of 10 seconds was given between each repetition.[3]

Hip abductor setting exercises: (10 repetitions×1set/day). For hip abductor setting exercises low intensity isometric contractions were performed against little to no resistance for hip abductors. The subjects were placed in supine position and subjects were instructed to perform hip abduction against mild resistance applied by therapist.[3]

ACTIVE-ASSISTED R.O.M

EXERCISES OF HIP: (10 repetitions×1 set /day)

10 repetitions of active assisted R.O.M of hip flexion and abduction were performed with the subjects in supine position. The subjects were instructed to perform hip flexion and abduction within available range, with the therapist supporting the subject's thigh and the ankle or foot."[3]

ACTIVE HIP EXERCISES:

STRAIGHT LEG RAISES: (10 repetitions/1 set/day)

10 repetitions of straight leg raise exercise were performed by the subjects in supine position. To stabilize the pelvis and low back, the opposite hip and knee were kept flexed, and the foot was placed flat on the exercise table. The subjects were then instructed to contract the quadriceps muscle & then lift the leg to about 45° of hip flexion while keeping the knee extended for 10 seconds. A rest time of 10 seconds was given between each repetition. Verbal exercise cue was given for the SLR exercise protocol, "maintain quadriceps contraction throughout the lifting and lowering of the leg".[3]

HIP EXTENSION EXERCISES: (with knee extension and flexion) (10 repetitions × 1 set/day) 10 repetitions of AROM of hip extension were performed by the subjects in prone lying. The subjects were instructed to lift the thigh while keeping the knee extended & with the therapist stabilizing the pelvis with the top hand."[3]

HIP ABDUCTION AND ADDUCTION EXERCISE: (10 repetitions × 1 set/day)

Support the patient's leg with the upper hand under the knee and the lower hand under the ankle. For full range of adduction, the opposite leg needs to be in a partially abducted position. Keep the patient's hip and knee in extension and neutral to rotation abduction and adduction are performed.[3]

HIP MUSCLE STRENGTHENING EXERCISE:

Hip flexors, extensors, abductors, and knee extensors (10 repetitions × 1 set/day) [17]

BALANCE TRAINING: (10 repetitions × 1 set/day)[18]

Sit to stand

Unilateral heel raises

Partial knee bends

Balance in single-leg stance

RESULTS

All data were analysed by using statistical software SPSS version 26. Before applying statistical tests, data were screened for normal distribution using Shapiro-wilk test. All the outcome measures were analysed at baseline and after 4 weeks of the treatment, by using appropriate statistical test. Level of significance was kept at 5%. Within group the data was analysed with paired t-test for Range of motion (ROM) and Wilcoxon signed rank test for Numerical pain rating scale (NPRS) and LEFS. Between group the data was analysed with Unpaired t test for Range of motion (ROM) and Mann-Whitney U test for Numerical pain rating scale (NPRS) and LEFS.

TABLE 1: GENDER DISTRIBUTION GROUP A & B

Gender	Female	Male	Total
Group A	8	7	15
Group B	7	8	15
Total	15	15	30

TABLE 2: AGE DISTRIBUTION GROUP A & B

AGE	NO.	MEAN AGE	SD	MIN	MAX
GROUP A	15	56	15.946	20	78
GROUP B	15	51.8	14.319	27	80

TABLE 3: MEAN DIFFERENCE IN NPRS WITHIN GROUP A & B

GROUP	PRE TREATMENT		POST TREATMENT		t/Z VALUE	P VALUE
	MEAN	SD	MEAN	SD		
GROUP A	6.333	1.83	1.667	0.816	12.935	0.000
GROUP B	6.666	0.976	4.267	0.704	9.431	0.000

The above table 3 shows the comparison of pre & post treatment scores of NPRS of Group A and B. Differences in the pre and post treatment mean values of group A and B were analyzed using Wilcoxon Sign Rank test for NPRS. The p value is <0.05. It shows that there is statistically significant difference between the pre and post treatment score of NPRS of group A and B.

TABLE 4: MEAN DIFFERENCE IN NPRS BETWEEN GROUP A & B

OUTCOME	GROUP A		GROUP B		P VALUE
	MEAN	SD	MEAN	SD	
NPRS	4.667	1.397	2.4	0.985	0.000

Table 4 shows the difference mean of group A & B. Mean values of both the groups were analysed using a Mann-WhitneyU test for NPRS. The p value is <0.05. It shows that there is statistically significant difference of NPRS between group A & B.

TABLE 5: MEAN DIFFERENCE IN ROM FLEXION WITHIN GROUP A & B

GROUP	PRE TREATMENT		POST TREATMENT		t/Z VALUE	P VALUE
	MEAN	SD	MEAN	SD		
GROUP A	79.333	27.442	121	11.68	-8.387	0.000
GROUP B	78.333	31.413	98.667	22.238	-4.357	0.000

TABLE 6: MEAN DIFFERENCE IN ROM ABDUCTION WITHIN GROUP A & B

GROUP	PRE TREATMENT		POST TREATMENT		t/Z VALUE	P VALUE
	MEAN	SD	MEAN	SD		
GROUP A	23.333	7.952	41.333	8.943	-3.492	0.000
GROUP B	25.067	9.83	31.067	9.09	-10.869	0.000

TABLE 7: MEAN DIFFERENCE IN ROM INTERNAL ROTATION WITHIN GROUP A & B

GROUP	PRE TREATMENT		POST TREATMENT		t/Z VALUE	P VALUE
	MEAN	SD	MEAN	SD		
GROUP A	16.2	6.338	30.2	3.985	-9.739	0.000
GROUP B	14.267	8.004	21.733	6.529	-9.888	0.000

TABLE 8: MEAN DIFFERENCE IN ROM EXTERNAL ROTATION WITHIN GROUP A & B

GROUP	PRE TREATMENT		POST TREATMENT		t/Z VALUE	P VALUE
	MEAN	SD	MEAN	SD		
GROUP A	19.067	5.587	37.667	5.601	-10.675	0.000
GROUP B	19.867	4.998	28.467	5.629	-9.459	0.000

TABLE 9: MEAN DIFFERENCE IN ROM BETWEEN GROUP A & B

OUTCOME	GROUP A		GROUP B		P VALUE
	MEAN	SD	MEAN	SD	
ROM FLEXION	41.667	19.241	20.333	18.097	0.004
ROM ABDUCTION	17.8	6.581	6	2.138	0.000
ROM INTERNAL ROTATION	14	5.568	7.467	2.924	0.000
ROM EXTERNAL ROTATION	18.6	6.75	8.6	3.521	0.000

Table 9 shows the difference mean of group A & B. Mean values of both the groups were analysed using a unpaired t-test for ROM. The p value is <0.05. It shows that there is statistically significant difference of ROM between group A & B.

TABLE 10: MEAN DIFFERENCE IN LEFS WITHIN GROUP A & B

GROUP	PRE TREATMENT		POST TREATMENT		t/Z VALUE	P VALUE
	MEAN	SD	MEAN	SD		
GROUP A	33.667	14.156	61.933	9.647	-9.063	0.000
GROUP B	25.933	12.87	45.533	10.169	-8.284	0.000

The above table 10 shows the comparison of pre & post treatment scores of LEFS of Group A and B. Differences in the pre and post treatment mean values of group A and B were analyzed using Wilcoxon Sign Rank test for LEFS. The p value is <0.05. It shows that there is statistically significant difference between the pre and post treatment score of LEFS of group A and B.

TABLE 11: MEAN DIFFERENCE IN LEFS BETWEEN GROUP A & B

OUTCOME	GROUP A		GROUP B		P VALUE
	MEAN	SD	MEAN	SD	
LEFS	28.266	12.079	19.6	9.163	0.035

Table 11 shows the difference mean of group A & B. Mean values of both the groups were analysed using a Mann-Whitney U test for LEFS. The p value is <0.05. It shows that there is statistically significant difference of LEFS between group A & B.

DISCUSSION

The present study showed that both conventional physical therapy and PNF hold-relax stretching combined with conventional physical therapy improved pain, hip range of motion (ROM), and function, but the PNF group improved

more.[19] This is consistent with evidence that PNF stretching can improve hip ROM and flexibility in musculoskeletal populations.[8,20] The findings suggest that PNF may provide additional clinical benefit when stiffness is the main problem.[6,19]

The greater reduction in pain in the PNF group may be related to the neuromuscular effects of hold-relax stretching, which can reduce muscle resistance and improve stretch tolerance. PNF is widely used to improve flexibility and ROM, although the exact mechanism remains debated.[5,21] Previous studies have shown that PNF can improve hip flexion ROM and flexibility, supporting its use in rehabilitation.[8,20]

The improvement in ROM in the present study is in line with earlier research showing that PNF techniques can increase hip flexion ROM in healthy adults and in participants with hamstring tightness.[8,20] A randomized clinical trial also found that hold-relax PNF improved hamstring flexibility immediately after intervention.[22] Systematic review evidence suggests that PNF can increase ROM, although the strength of evidence varies depending on the comparison and population.[23]

Functional improvement was also greater in the PNF group, indicating that gains in pain and ROM translated into better daily activity performance.[19] LEFS is a valid and responsive outcome measure for lower-extremity conditions and fractures, making it suitable for assessing functional change in this population.[10,15] The broader hip rehabilitation literature also supports exercise-based rehabilitation for improving mobility and function after hip fracture or hip surgery.[4,18,24,25]

The superiority of PNF hold-relax may be explained by autogenic inhibition during the isometric contraction phase, followed by a greater stretch in the relaxed phase. This mechanism may help reduce reflexive muscle resistance and increase tolerance to stretch.[5,21] In the context of post-immobilization stiffness, where soft tissue tightness and joint restriction are common, this may be particularly useful.[19]

The control group also improved, which shows that conventional physiotherapy alone remains beneficial for pain and mobility recovery.[19] However, the larger gains in the experimental group suggest that combining conventional treatment with PNF hold-relax may be more effective than exercise alone when stiffness is marked. This supports a multimodal rehabilitation approach rather than relying on one method only.[19,4,18]

The outcome measures used in this study are supported by previous literature. NPRS is commonly recommended for pain assessment, goniometry has acceptable reliability for ROM measurement, and LEFS has good measurement properties for lower-extremity function. Therefore, the improvements observed in this study are likely to reflect true clinical change.[10,15,19]

The study has limitations, including a small sample size, convenience sampling, and a short follow-up period. These factors limit generalizability and do not confirm whether the benefits persist over time.[19] Future randomized controlled trials with larger samples and longer follow-up are needed to confirm these findings.[4,23] Despite these limitations, the results support the use of PNF hold-relax stretching as an effective adjunct to conventional physical therapy in post-immobilization hip stiffness.[19]

CONCLUSION

In conclusion, the study investigating the effects of proprioceptive neuromuscular facilitation (PNF) stretching on post-immobilization hip stiffness yielded promising results. Both Group A receiving PNF stretching along with conventional physical therapy, and Group B, receiving conventional physical therapy alone, showed significant improvements in pain intensity, hip range of motion, and function after 4 weeks. However, the group which received PNF stretching along with conventional physical therapy produced a significantly greater decline in the pain intensity, improvement in ROM and

function, when compared to conventional physical therapy alone.

Declaration by Authors

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