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Effectiveness of Lower Limb Proprioceptive Neuromuscular Facilitation on ADL in Stroke Subjects

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ABSTRACT

Background: One of the main causes of disability is stroke, which frequently results in decreased motor function and a diminished capacity to perform daily living activities (ADLs). The rehabilitation method known as Proprioceptive Neuromuscular Facilitation (PNF) enhances neuromuscular control, strength, and coordination, which may improve functional independence in stroke survivors.
Objective: This study sought to assess the efficacy of lower limb PNF in improving ADL performance in individuals with chronic stroke.
Methods: A quasi-experimental pretest-posttest study was conducted with 30 Patients with chronic stroke were randomized to an experimental group. (n=15) receiving PNF-based lower limb training and a control group (n=15) undergoing conventional physiotherapy. Used the Timed Up and Go (TUG) test to assess functional mobility and the Barthel Index (BI) was used to evaluate the ADL performance before and after the four-week intervention.
Results: Comparing the control group to the experimental group showed notable gains in ADL. The BI scores rose from an average of 60.3 to 75.6 (p=0.000), while the control group showed a smaller increase from 59.8 to 68.2 (p=0.003). Similarly, the TUG test performance improved significantly in the experimental group (pre-test: 27.5 sec, post-test: 21.3 sec, p=0.000) in contrast to the control group (pre-test: 28.1 sec, post-test: 24.8 sec, p=0.004). Independent t-tests confirmed a significant difference between groups (BI: t=2.98, p=0.002; TUG: t=3.21, p=0.001).
Conclusion: Lower limb PNF effectively enhances functional mobility and ADL performance in stroke patients by improving neuromuscular coordination, strength, and postural control. Incorporating PNF into stroke rehabilitation programs may promote increased self-reliance and a higher standard of living. Further research is advised to investigate long-term impacts and suitability for varying stroke severity.

Keywords: Stroke, proprioceptive neuromuscular facilitation, ADL, rehabilitation, functional mobility, postural control.

INTRODUCTION

One of the primary causes of long-term disability, stroke significantly affects a person's independence and quality of life.[1] Hemiparesis is the most common symptom following a stroke.[2] It occurs due to a

disruption in the blood flow to the brain, resulting in ischemic or damage to brain tissue caused by bleeding, which in turn leads to impairments in motor function, sensation, cognition, and speech.[3] Among these impairments, motor deficits, particularly in the lower limbs, pose a major challenge for stroke survivors, because they directly impact the mobility and the capacity to carry out ADL's.[4] Perceptual deficits, motor function impairment, balance problems, visual deficits, cognitive limitations, aphasia, and depression are common post-stroke complications that restrict a patient's capacity to stand, walk, and perform daily activities.[5,6] A sedentary lifestyle and deconditioned state are common among stroke survivors, which also restricts daily activities.[7] Rehabilitation plays a critical role in restoring function and promoting independence, with various therapeutic approaches employed to enhance neuromuscular control and movement efficiency.

One such rehabilitation strategy is PNF, a method extensively employed to improve coordination, strength, flexibility, and functional mobility in individuals with neuromuscular impairments.[8] PNF was originally developed in the 1940s and is based on the principles of neurophysiological facilitation, where specific movement patterns are used to stimulate proprioceptors and enhance neuromuscular responses.[9] The technique incorporates diagonal movement patterns, rhythmic initiation, manual resistance, and irradiation to facilitate motor learning and improve functional movements.[10] These movement patterns mimic natural human motion, engaging multiple muscle groups in a coordinated manner, making them particularly effective for stroke rehabilitation.[11]

Significance of Lower Limb PNF in Stroke Rehabilitation

The use of lower limb PNF has drawn a lot of interest in stroke recovery because of its capacity to enhance gait, balance, postural control, and overall mobility.[12] Studies suggest that PNF techniques can improve motor control by reinforcing proper movement sequences, increasing muscle activation, and enhancing weight-bearing capacity in stroke patients.[13] The repetitive nature of PNF exercises promotes motor relearning and neuromuscular adaptation, essential for restoring functional independence.[14]

A comparative study by Wang and Xu (2019) demonstrated that stroke patients undergoing lower limb PNF training showed greater improvements in balance and mobility compared to those receiving conventional physiotherapy alone.[12] Similarly, Kim et al. (2020) found that PNF-based gait training improved step length, stride symmetry, and walking speed, leading to better overall functional outcomes.[15] The effectiveness of PNF in post-stroke rehabilitation may be attributed to its ability to stimulate sensory feedback mechanisms, facilitating improved postural adjustments and dynamic stability.[10]

PNF and Activities of Daily Living (ADL)

ADLs are crucial indicators of functional independence, and their restoration is a primary goal in stroke rehabilitation.[16] Common ADLs affected by stroke include walking, dressing, bathing, toileting, and transferring.[17] The application of lower limb PNF aims to enhance lower extremity strength and coordination, thereby enhancing a patient's performance on these tasks independently.[18] The Barthel Index (BI), a widely used ADL assessment tool, has shown significant improvements in stroke patients following PNF-based interventions, suggesting its effectiveness in promoting functional independence.[12]

Moreover, integrating PNF with conventional rehabilitation methods, such as task-oriented training and functional electrical stimulation, has been proposed as an effective strategy for maximizing ADL recovery.[3] However, despite its benefits, additional investigation is required to

ascertain the optimal PNF protocols, dosage, and long-term effects on stroke patients.[13]

Rationale for the Study

Despite increasing evidence supporting PNF in stroke rehabilitation, there remains a gap in research regarding its direct impact on ADL performance compared to traditional physiotherapy methods. This study aims to bridge this gap by assessing the effectiveness of lower limb PNF in improving ADLs in stroke patients and evaluating its clinical significance in rehabilitation settings. By examining objective measures such as the Barthel Index (BI) and the Timed Up and Go (TUG) test, this research seeks to give insightful explanations of how PNF improves functional independence.

MATERIALS & METHODS

Study Design: A quasi-experimental pretest-posttest study was conducted with stroke patients undergoing rehabilitation.

Participants:

Thirty stroke patients (n=30) were recruited and assigned at random to the experimental group (n=15) receiving lower limb PNF training or the control group (n=15) undergoing conventional physiotherapy. Inclusion criteria were: (1) a minimum of six months' history of stroke, (2) ability to follow verbal instructions, and (3) partial weight-bearing capacity. Patients with severe cognitive deficits, uncontrolled hypertension, or orthopedic conditions affecting mobility were excluded.

Intervention:

- **Experimental Group:** Lower limb PNF training was provided for four weeks, five sessions per week, each lasting 45 minutes. The intervention focused on PNF diagonal patterns, rhythmic initiation, and resistance training.
- **Control Group:** Conventional physiotherapy, including muscle strengthening, gait training, and balance exercises, was administered for an equivalent duration.

Outcome Measures:

1. **Barthel Index (BI):** Measures ADL performance (0-100 scale, higher scores indicate greater independence).
2. **Timed Up and Go (TUG) Test:** evaluates mobility in function (measured in seconds, lower values indicate better mobility).

STATISTICAL ANALYSIS

Pairwise and using independent t-tests, the study looked at the scores before and after the intervention. Statistical significance was defined as having p-values below 0.05.

RESULT

Table 1: Pre and Post-Intervention Scores for BI and TUG

Group	BI Pre (Mean ± SD)	BI Post (Mean ± SD)	p-value	TUG Pre (Mean ± SD)	TUG Post (Mean ± SD)	p-value
Experimental	60.3 ± 6.8	75.6 ± 5.4	0.000	27.5 ± 4.1	21.3 ± 3.8	0.000
Control	59.8 ± 7.2	68.2 ± 5.9	0.003	28.1 ± 3.9	24.8 ± 4.2	0.004

The table presents the comparative analysis of the BI scores and TUG test results before and after the intervention in both the experimental group (receiving lower limb PNF) and the control group (receiving conventional physiotherapy).

Barthel Index (BI) Scores:

Higher scores on the BI indicate greater independence. The BI is used to evaluate a patient's capacity to perform daily living activities (ADL). Prior to the intervention, the mean for the experimental group was BI score of 60.3 ± 6.8, whereas the group under control had a similar mean score of 59.8 ± 7.2. After completing the intervention, the

experimental group showed a notable improvement, with a post-intervention mean BI score of 75.6 ± 5.4. The control group also showed an improvement, but to a lesser extent, with a post-intervention mean score of 68.2 ± 5.9. The p-values (0.000 regarding the experimental group and 0.003 regarding the control group) show that the experimental group experienced a greater impact and that these improvements were statistically significant.

Timed Up and Go (TUG) Test Results:
By measuring how long it takes a participant to get out of a chair, the TUG test assesses functional mobility, walk a short distance, and return to a seated position. Lower scores indicate better mobility. Initially, the experimental group's mean was recorded a TUG score of 27.5 ± 4.1 seconds, whereas the mean score for the control group was 28.1 ± 3.9 seconds. After the intervention, both groups demonstrated improvement, with the experimental group reducing their time to 21.3 ± 3.8 seconds and the control group to 24.8 ± 4.2 seconds. The observed improvements were statistically significant (p-values: 0.000 regarding the experimental group and 0.004 regarding the control group), with the experimental group exhibiting a greater reduction in TUG time, indicating superior mobility gains.

Interpretation:
The results suggest that both interventions were successful in increasing mobility and ADL performance, but lower limb PNF produced greater improvements compared to conventional physiotherapy. The significantly higher BI score and greater reduction in TUG time in the experimental group indicate that PNF is a more effective rehabilitation approach for enhancing functional independence in stroke patients.

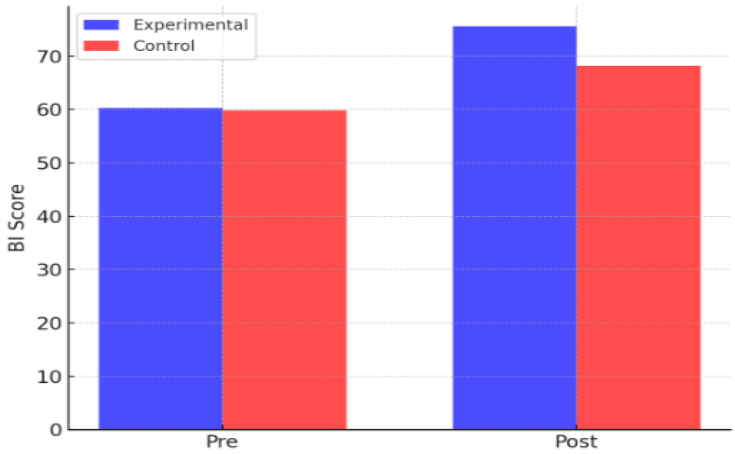

Figure 1: Comparison of Pre- and Post-Intervention BI Scores

This graph presents a visual comparison of the Barthel Index (BI) scores before and after the intervention for both the experimental group (PNF-based training) and the control group (conventional physiotherapy). The BI assesses a patient's ability to perform basic self-care and daily activities, with higher scores indicating greater independence.

- On the horizontal axis (X-axis), the two groups are displayed: Experimental and Control. Each group has two bars representing pre- and post-intervention BI scores.
- The vertical axis (Y-axis) represents BI scores ranging from 0 to 100.

Observations from the graph:

- The experimental group started with a mean BI score of 60.3, which increased to 75.6 after four weeks of lower limb PNF therapy. This improvement of 15.3 points reflects a marked enhancement in functional independence.

- The control group improved from 59.8 to 68.2, with an increase of 8.4 points, which is statistically significant but less pronounced than the experimental group.
- The difference in height between the pre- and post-bars is larger in the experimental group, clearly indicating a greater gain in ADL performance compared to the control group.

This visual data underscores the clinical advantage of PNF techniques in improving a patient's ability to carry out daily tasks independently. The greater increase in BI scores for the experimental group suggests that the functional training offered through PNF patterns may be more effective in restoring autonomy and reducing dependency on caregivers compared to standard physiotherapy approaches.

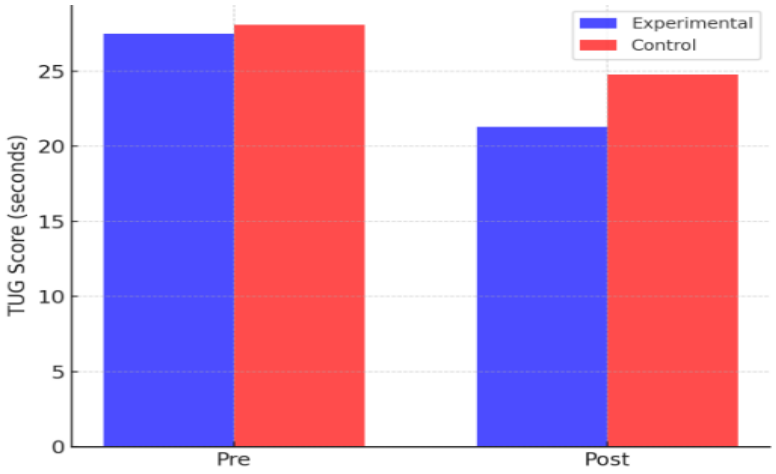

Figure 2: Comparison of Pre- and Post-Intervention TUG Scores

This graph illustrates the results of the Timed Up and Go (TUG) test, which measures functional mobility by recording the time a person takes to rise from a seated position, walk a short distance, turn around, return, and sit back down. Lower scores reflect better mobility.

- The X-axis again shows the two groups—Experimental and Control—with separate bars for pre- and post-intervention times.
- The Y-axis displays the TUG scores in seconds, with lower values indicating improved performance.

Observations from the graph:

- The experimental group reduced their TUG time from 27.5 seconds before the intervention to 21.3 seconds after, a 6.2-second improvement.
- The control group showed a smaller improvement, from 28.1 seconds to 24.8 seconds, which is a 3.3-second decrease.
- The taller bars in the pre-intervention stage for both groups become shorter post-intervention, but the reduction is more pronounced in the PNF group.

The significant drop-in TUG time for the experimental group reflects improved balance, speed, and coordination—key indicators of functional recovery in stroke rehabilitation. PNF training likely contributed to enhanced neuromuscular control and movement efficiency, leading to better real-world mobility outcomes than conventional therapy. This improvement may reduce the risk of falls and improve patients' confidence in ambulation.

DISCUSSION

The findings of this study demonstrate that Proprioceptive Neuromuscular Facilitation (PNF) training significantly enhances functional mobility and the ability to perform activities of daily living (ADLs) in individuals with chronic stroke. This outcome supports the hypothesis that lower

limb PNF, by promoting neuromuscular coordination and postural control, contributes to better rehabilitation outcomes when compared to conventional physiotherapy.

Stroke survivors often exhibit motor impairments, especially in the lower limbs, which compromise their independence in ADLs and mobility.[4] The primary aim of rehabilitation in such individuals is to restore function through techniques that stimulate neuroplasticity and promote motor relearning. PNF is one such approach that utilizes specific movement patterns to activate proprioceptors and facilitate coordinated muscular responses.[19]

In the current study, the experimental group receiving PNF training demonstrated a substantial improvement in the Barthel Index (BI), rising from a pre-intervention average of 60.3 to 75.6 post-intervention. In contrast, the control group exhibited a smaller improvement, from 59.8 to 68.2. This statistically significant difference indicates that PNF exercises, which incorporate diagonal and spiral patterns simulating functional activities, may better promote ADL performance. These findings are consistent with previous research suggesting that PNF is more effective than conventional therapy in improving self-care, mobility, and independence in stroke patients.[12]

The improvement in the Timed Up and Go (TUG) test performance among the PNF group further supports these results. The group demonstrated a notable reduction in completion time - from 27.5 seconds pre-intervention to 21.3 seconds post-intervention - indicating enhanced dynamic balance, strength, and walking efficiency. This finding is significant because the TUG test is a reliable indicator of functional mobility and fall risk.[20] Improvements in this domain can directly translate to increased confidence and reduced dependency in everyday tasks.

The effectiveness of PNF may be attributed to its emphasis on functional movement patterns that replicate daily activities, unlike conventional therapy which often isolates muscle groups. The resistance and facilitation applied during PNF sessions are believed to engage both agonist and antagonist muscles synergistically, promoting better intermuscular coordination.[8] Additionally, the consistent sensory input provided through manual contact and verbal cues may enhance motor planning and proprioceptive awareness, essential for regaining mobility post-stroke.[15]

Moreover, PNF incorporates rhythmic initiation and progressive resistance, which may aid in reducing spasticity and improving muscle strength—factors critical for stroke rehabilitation.[21] The comprehensive activation of muscles, including those of the trunk and pelvis, may also contribute to better postural stability, which is often compromised in hemiparetic individuals.[22]

CONCLUSION

This study provides strong evidence that lower limb Proprioceptive Neuromuscular Facilitation (PNF) is a highly effective intervention for improving functional mobility and activities of daily living (ADLs) in individuals with chronic stroke. The significant improvements observed in the Barthel Index (BI) and Timed Up and Go (TUG) test scores among participants in the experimental group highlight the practical benefits of incorporating PNF into rehabilitation programs.

Compared to conventional physiotherapy, PNF training resulted in more substantial gains in both independence and mobility. This suggests that the unique approach of PNF - which emphasizes diagonal movement patterns, proprioceptive stimulation, and neuromuscular coordination - better facilitates motor recovery in stroke-affected individuals. These elements work together to enhance muscle activation, postural control, and balance, all of which are crucial for performing everyday tasks.

The improvement in BI scores reflects greater independence in essential self-care activities such as dressing, bathing, and transferring. Similarly, the reduction in TUG test time indicates better gait efficiency and reduced fall risk, both of which are important for ensuring safe ambulation in stroke patients. Together, these outcomes reinforce the clinical relevance and applicability of PNF in neurorehabilitation settings.

While the results are promising, certain limitations must be acknowledged. The sample size was limited to 30 participants, and the duration of the intervention was only four weeks. Additionally, the study did not assess long-term retention of the functional gains or the impact of PNF on different stroke subtypes or severities. Future research should consider larger sample sizes, extended intervention periods, and follow-up assessments to better understand the sustained effects of PNF.

In conclusion, the incorporation of lower limb PNF in stroke rehabilitation protocols offers a promising strategy to accelerate recovery, enhance independence, and improve overall quality of life for stroke survivors. Given its effectiveness and simplicity, PNF should be considered a valuable addition to conventional physiotherapy for patients undergoing post-stroke rehabilitation.

Limitations and Future Recommendations:

Limitations:

Despite the encouraging results, certain limitations must be acknowledged. The study's sample size was relatively small (n=30), and the duration was limited to four weeks and there was Lack of blinding, which could introduce bias. Long-term follow-up data was not collected, making it difficult to determine the sustainability of the improvements.

Future Recommendations:

Future research with larger, more diverse populations and extended intervention periods is necessary to confirm these findings, establish standardized PNF protocols for stroke rehabilitation, investigate the combination of PNF with other rehabilitation techniques and explore neurophysiological mechanisms underlying PNF-induced improvements.

Declaration by Authors

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Conflict of Interest: The authors declare no conflict of interest.

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