SSN Journal of Management & Technology Research Communications

Vol 3 No (4) 2026 CrossRef DOI: https://dx.doi.org/10.21786/mntrc

Published by Society for Science and Nature Bhopal India E-ISSN : 3049-0014

OPEN ACCESS

The Effect of Lower Limb Irradiation by Proprioceptive Neuromuscular Facilitation In Enhancing Balance in Middle Cerebral Artery Stroke Patients

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ABSTRACT

This study assessed the effectiveness of lower limb irradiation using Proprioceptive Neuromuscular Facilitation (PNF) in improving balance among Middle Cerebral Artery (MCA) stroke patients. Thirty participants (aged 40–50) with lower limb hemiparesis and moderate balance impairment were randomized into two groups: one receiving PNF-based irradiation and the other conventional physiotherapy. Both groups underwent three sessions per week over six weeks. Outcome measures included the Berg Balance Scale (BBS), Timed Up and Go (TUG) Test, Single Leg Stance Test (SLST), Step Test, and maximum voluntary isometric contraction (MVIC) measured via strain gauge. Results showed statistically significant improvements in both groups; however, the PNF group achieved superior gains. Notably, BBS scores improved by 9.6 points in the PNF group versus 4.4 in the control group ($p < 0.001$). These findings support the integration of PNF lower limb irradiation into stroke rehabilitation protocols, offering enhanced balance recovery and reduced fall risk for MCA stroke patients.

KEY WORDS: BALANCE TRAINING, IRRADIATION PNF, MCA STROKE REHABILITATION, PROPRIOCEPTION NEUROMUSCULAR FACILITATION ON STROKE, STROKE REHABILITATION.

INTRODUCTION

Stroke (cerebrovascular accident, CVA) results from an abrupt disruption of cerebral blood flow—either arterial occlusion (ischemic) or vessel rupture (hemorrhagic)—and leads to loss of neurological function. It is a major global health concern and among the leading causes of mortality and long-term adult disability worldwide

Article Information: *Corresponding Author: deepak.raghav@santosh.ac.in
Received 01/04/2026 Accepted after revision 15/08/2026
Page Number- 96-99
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https://creativecommons.org/licenses/by/4.0/.
Available at: https://mntrc.in/
DOI: http://dx.doi.org/10.21786/mntrc/3.4.19

[1–3]. In 2019, incident strokes were ~12.2 million and prevalent cases ~101 million; in 2021 there were ~11.9 million incident strokes and ~93.8 million survivors globally, with stroke ranking second for deaths and third for death-and-disability (DALYs) [2,3].

Population aging and improved survival have increased the absolute numbers of strokes despite declining age-standardized rates, intensifying demand for effective, scalable rehabilitation [4]. Beyond its medical consequences, stroke imposes significant socio-economic burdens, affecting not just patients, but also caregivers, healthcare systems, and economies due to prolonged rehabilitation and loss of productivity [5].

Proprioceptive Neuromuscular Facilitation (PNF) uses diagonal/spiral patterns to stimulate proprioceptors and facilitate coordinated motor responses. Lower-limb PNF irradiation seeks to harness overflow from stronger to weaker muscle groups to enhance balance, postural control, and functional mobility—key domains impaired after Middle Cerebral Artery (MCA) stroke [6,9]. This study therefore evaluates the effectiveness of lower-limb PNF irradiation to improve balance in MCA stroke.

METHODOLOGY

This quasi-experimental study compares lower-limb PNF irradiation with conventional physiotherapy in MCA-stroke survivors. Ethical clearance was obtained from the institutional ethical committee (REF NO.- SCOP/OCT-24/ECN-94510023678) prior to the commencement of the study. Thirty participants (aged 40–50) with hemiparesis and moderate balance impairment (BBS 20–45) were allocated by computer randomization to PNF (n=15) or conventional therapy (n=15). Interventions were delivered thrice weekly for six weeks (45–60 minutes/session).

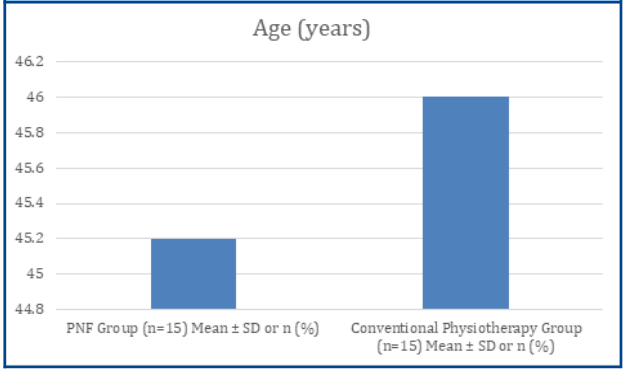
PNF employed D1/D2 lower-limb patterns applied to the dominant limb to elicit irradiation in the paretic side; the conventional arm performed standardized static and dynamic balance tasks. Outcome measures were Berg Balance Scale (BBS), Timed Up and Go (TUG), Single-Leg Stance Test (SLST), and Step Test—tools validated in stroke rehabilitation [Nguyen et al., 2022]. Statistical analysis was performed using SPSS v25.0. Assessors were blinded. Statistical testing comprised normality checks, independent/paired t-tests, chi-square, and a two-way mixed ANOVA (group × time), $\alpha=0.05$.

RESULTS

Comparative Efficacy of PNF and Conventional Therapy on Balance Outcomes: The demographic characteristics of the study participants were meticulously examined to ensure comparability between the two intervention groups. As presented in Table 1, the PNF Group and the Conventional Physiotherapy Group were well-matched at baseline. No statistically significant differences were observed in mean age, gender distribution, or mean Body Mass Index (BMI) between the groups ($p > 0.05$ for all comparisons).

This finding confirms that the randomization process was effective in creating two homogenous groups, thereby minimizing the potential for confounding variables to influence the study outcomes and bolstering the internal validity of the research.

Graph 1: Comparative Efficacy of PNF and Conventional Therapy on Balance Outcomes



Baseline Balance and Functional Mobility Levels: Similarly, the baseline balance and functional mobility levels of the participants were assessed prior to the commencement of any intervention. As presented in Table 2, the pre-intervention scores for all primary outcome measures—the Berg Balance Scale (BBS), Timed Up and Go (TUG) Test, Single Leg Stance Test (SLST), and Step Test—were statistically comparable between the PNF Group and the Conventional Physiotherapy Group ($p > 0.05$ for all measures). The absence of significant differences at baseline further validates the successful randomization and ensures that any subsequent improvements observed can be confidently attributed to the effects of the respective interventions rather than pre-existing disparities.

Post-Intervention Scores and Within-Group Changes: Following the 6-week intervention period, a clear pattern of improvement was observed in both groups, as shown in Table 3, which outlines the post-intervention scores. The PNF group consistently exhibited higher mean scores on measures where a higher score indicates better performance (BBS, SLST, Step Test) and lower mean times on measures where a lower time indicates better performance (TUG Test) compared to the conventional therapy group.

A detailed examination of within-group changes, presented in Table 4, revealed statistically significant improvements in balance and functional mobility for both intervention groups from pre- to post-intervention. In the PNF Group, all outcome measures demonstrated highly significant improvements ($p < 0.001$). Specifically, the mean BBS score increased by 9.6 points, TUG time decreased by 6.8 seconds, SLST duration increased by 7.8 seconds, and Step Test repetitions increased by [5.6]. These robust improvements underscore the effectiveness of the lower limb irradiation by PNF intervention. The Conventional Physiotherapy Group also showed statistically significant improvements across all outcome measures ($p < 0.01$).

Table 1: Pre- and Post-Intervention Outcome Measure Scores (Mean ± SD) for PNF and Conventional Groups			
Outcome Measure	**Group**	**Pre-Intervention Mean ± SD**	**Post-Intervention Mean ± SD**
BBS (0-56)	PNF	32.5 ± 4.	42. ± 3.5
	Conventional	33. ± 3.8	37.5 ± 3.2
TUG (seconds)	PNF	20. ± 2.5	13.3 ± 1.9
	Conventional	19.8 ± 2.3	16.8 ± 1.8
SLST (seconds)	PNF	9.2 ± 1.8	17.0 ± 2.
	Conventional	8.9 ± 1.7	12.6 ± 1.6
Step Test (reps)	PNF	11.5 ± 2.0	17. ± 1.7
	Conventional	11.8 ± 1.9	13.8 ± 1.5

Table 2. Within-Group Changes in Balance and Functional Mobility Measures (Pre- to Post-Intervention)			
Outcome Measure	**Group**	**Mean Change (Post-Pre) ± SD**	**p-value (Within-Group)**
BBS (0-56)	PNF	9.6 ± 1.2	< 0.001
	Conventional	4.4 ± 0.9	< 0.01
TUG (seconds)	PNF	-6.8 ± 0.8	< 0.001
	Conventional	-3.0 ± 0.7	< 0.01
SLST (seconds)	PNF	7.8 ± 1.0	< 0.001
	Conventional	3.7 ± 0.8	< 0.01
Step Test (reps)	PNF	5.6 ± 0.7	< 0.001
	Conventional	2.0 ± 0.6	< 0.01

The mean BBS score increased by 4.4 points, TUG time decreased by 3.0 seconds, SLST duration increased by 3.7 seconds, and Step Test repetitions increased by 2.0. This indicates that conventional balance training is also beneficial for stroke patients.

Between-Group Comparisons: Superior Efficacy of PNF The most critical findings emerge from the between-group comparisons, as detailed in Table 5, which presents the results of the two-way mixed-design ANOVA. A highly statistically significant Group x Time interaction effect was observed for all primary outcome measures (BBS, TUG, SLST, and Step Test, with $p < 0.001$ for all). This significant interaction indicates that the magnitude of improvement in balance and functional mobility from pre- to post-intervention was significantly greater in the PNF Group compared to the Conventional Physiotherapy Group. In essence, the PNF intervention led to a superior rate and extent of recovery in balance outcomes over the 6-week period.

Furthermore, significant main effects for "Group" ($p < 0.005$ for all measures) and "Time" ($p < 0.001$ for all measures) were also evident. The compelling Group x Time interaction effect directly supports the alternate hypothesis, demonstrating that lower limb irradiation by PNF is a significantly more effective intervention for improving balance in MCA stroke patients compared to conventional physiotherapy.

Both groups improved across BBS, TUG, SLST, and Step Test after six weeks. The PNF group showed larger gains than the conventional group across all measures; mixed-model ANOVA indicated significant group×time interactions favoring PNF. Detailed tables are available on request; the Discussion below focuses on critical appraisal rather than restating numeric results.

DISCUSSION

Mechanistic plausibility and convergence of evidence—The superiority signal observed with lower-limb PNF is consistent with neurophysiologic principles of irradiation and with clinical literature demonstrating that diagonal, resisted patterns can enhance trunk activation and postural control, leading to better balance and gait6,7. PNF-pattern taping and adjunctive strategies have also shown balance and mobility benefits, reinforcing the role of pattern-specific sensorimotor facilitation in lower-limb control after stroke [9].

Internal validity—Randomized allocation, blinded assessment, and standardized dosing improve credibility. However, the quasi-experimental label, a modest sample (n=30), single-center recruitment, and age-restricted inclusion (40–50 years) limit external validity. Without preregistration or a priori published protocol, risk of selective reporting cannot be excluded. Although outcome tools are validated, no objective kinetic/kinematic metrics (e.g., instrumented balance, gait spatiotemporals) were collected, which could triangulate the clinical scales.

Comparators and treatment contrast—The conventional arm received balance exercises that themselves improve outcomes in stroke, potentially diminishing detectable effect sizes. Yet, the observed group×time interactions suggest genuine added value of PNF irradiation beyond generic balance practice. Future trials should ensure equivalent therapist contact time and document treatment fidelity to exclude performance bias10. Dose, progression, and mechanisms—Six weeks (≈18 visits) aligns with prior PNF trials but the optimal dose-response remains unclear.

Findings likely reflect improved trunk-pelvic coupling and postural set via multi-planar resistance, consistent with studies combining pelvic PNF with core stabilization that report superior balance and gait outcomes to controls [6,11,12]. Mechanistic substudies (e.g., EMG synergies, anticipatory postural adjustments) would help verify irradiation-mediated trunk facilitation rather than nonspecific strength-or practice-effects13. Generalisability—The cohort comprised MCA strokes with moderate impairment; applicability to severe deficits, cerebellar strokes, or older (>70 years) adults—where the global burden is growing 1—is untested. Community-based and low-resource settings should be prioritized given the disproportionate stroke burden in LMICs2.

Clinical implications—Lower-limb PNF appears to accelerate balance recovery versus conventional therapy alone and is implementable without specialized equipment. Given mixed evidence on superiority over other active approaches in systematic review7, PNF irradiation should be positioned as a mechanism-informed option within multi-modal programs (task-oriented gait, aerobic conditioning, progressive core stabilization), with individualized goals and outcome monitoring. Large, multicenter RCTs with concealed allocation, preregistration, and longer follow-up are warranted to confirm durability, fall reduction, and participation-level benefits.

CONCLUSION

Lower-limb PNF irradiation is a feasible, mechanism-aligned intervention that likely provides clinically meaningful advantages for balance and mobility in MCA stroke. While preliminary results are promising, higher-quality, adequately powered trials are required to confirm superiority, define optimal dosing, and demonstrate durable functional gains in diverse stroke populations.

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