

EFFECT OF PROPRIOCEPTIVE NEUROMUSCULAR FACILITATION COMBINED WITH CONVENTIONAL PHYSIOTHERAPY ON MOTOR RECOVERY AND FUNCTIONAL INDEPENDENCE IN PATIENTS WITH STROKE: A RANDOMIZED CONTROLLED TRIAL

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ABSTRACT

Objectives: To evaluate the impact of using Proprioceptive Neuromuscular Facilitation (PNF) in conjunction with conventional physiotherapy for improving motor function and independence in patients with stroke.

Methods: The randomized controlled study involved 40 stroke patients assigned evenly into two groups; experimental (n=20) undergoing treatment with PNF together with physiotherapy, and control (n=20) undergoing physiotherapy alone. The treatment was provided for six weeks, five days each week, with each session taking 45-60 minutes. Motor recovery was measured using the Fugl-Meyer Assessment (FMA) and functional independence using the Barthel Index (BI). Differences between groups in terms of changes in score values were compared using independent samples t-test.

Results: Improvements were observed in both the groups after the intervention. In terms of FMA score, the experimental group improved more with mean of 10.60 ± 2.58 compared to the control group's 6.53 ± 2.67 ($t = 4.899$, $p < 0.001$). Likewise, in terms of BI score, the experimental group improved with mean of 14.34 ± 5.63 compared to the control group's 7.76 ± 2.31 ($t = 4.842$, $p < 0.001$).

Conclusion: Conventional physiotherapy combined with PNF resulted in better motor recovery and functional independence as compared to conventional physiotherapy alone within six weeks. Thus, PNF can be regarded as complementary therapy rather than replacement for conventional stroke therapy.

Keywords: Stroke; Proprioceptive Neuromuscular Facilitation; Physiotherapy; Motor Recovery; Functional Independence; Fugl-Meyer Assessment; Barthel Index.

INTRODUCTION

Stroke is a common cause of acquired disabilities and often leads to lifelong problems with motor function, which require treatment and rehabilitation. (1, 2) The effects of stroke in the area of movement dysfunction usually

consist of weakness, inability to activate muscles, poor selective motor control, poor coordination and postural control. This may affect functions of the upper and lower extremities and hinder activities such as walking, transfer and dressing. Consequently,

the modern approach to stroke rehabilitation stresses the recovery of motor function as well as functional performance. (3, 4)

Traditional physiotherapy continues to be an integral part of the stroke recovery process and includes range of motion exercises, strengthening, balance training, gait training, task specific practice, and functional training. Research has shown that therapeutic exercise after a stroke is able to enhance physical abilities, and a multidisciplinary approach could tackle various aspects of motor deficit within one program. (5, 6) Still, differences in treatment responses and rehabilitation methods have prompted further research into supplementary methods which might boost the efficacy of traditional treatments. (7)

Proprioceptive Neuromuscular Facilitation (PNF) is an approach that incorporates proprioceptive stimulation, resistance, touch, verbal commands, and coordination in order to achieve optimal performance of neuromuscular functions. This approach is important in stroke rehabilitation since movement entails the coordination of various factors including sensory perception, motor control, and posture. (8) Previous research has demonstrated that proprioceptive exercises can enhance balance, core stability, gait speed, and functional mobility post-stroke, (9) although PNF-based physiotherapy has also shown positive outcomes on balance and gait among patients with chronic stroke. (10)

Nevertheless, existing studies differ from each other on a number of aspects including patient population, interventions used, time period for the intervention and outcomes measured. This difference complicates further understanding of the value of PNF therapy combined with regular physical therapy program. Recent evidence shows that proprioceptive therapy can be especially effective as part of more complex rehabilitation program. (11)

These two measures of treatment success are interrelated but different aspects of patient care. Changes in one area do not mean that changes will occur in the other; thus, functional independence should also be assessed. (12, 13) A number of rehabilitation techniques such as neuromuscular electrical stimulation, self-rehabilitation, and mirror treatment have been found to be helpful in enhancing everyday

activities. (14-16). However, with more research showing that proprioceptive and PNF therapies can be useful in rehabilitation, the effects that PNF therapy can add to conventional physiotherapy remain unclear. (17)

For that reason, this research was conducted in order to establish whether the inclusion of PNF in conventional physiotherapy would lead to more significant gains in motor and functional recovery in comparison with conventional physiotherapy. It was hypothesized that participants undergoing PNF and conventional physiotherapy would show better scores for FMA and BI scales.

Methodology

Study Design and Setting

A randomized control trial design was employed to test the effects of conventional physiotherapy alone against the effects of conventional physiotherapy coupled with PNF on stroke patients. This research was carried out in the physiotherapy or rehabilitation department of a selected hospital. The research took six months to complete.

Participants and Sample Size

For this research study, only adults that had been diagnosed with strokes and fulfilled the predefined eligibility criteria were considered. Calculation of the required sample size was done by using G*Power software version 3.1.9.7 with $\alpha=0.05$ and statistical power of 80% ($1-\beta=0.80$), resulting in a total of 40 participants. There was an even distribution between experimental and control groups (20 in each).

Eligibility Criteria

The inclusion criteria included: stroke diagnosis; 1 to 6 months after stroke; age of 40 to 70 years; having one-sided motor deficit; medical fitness for physiotherapy treatment; and understanding of the treatment procedure. Recurrent stroke, cognitive or communication deficits making it impossible to participate in the study; other neurodegenerative disorders interfering with motor function; musculoskeletal disorders making participation in the study impossible; uncontrolled cardiovascular or other illnesses; participation in another rehabilitation program; and pain.

Randomization and Allocation

Participants were allocated at random in a 1:1 ratio following their initial screening through the use of computer generated random numbers. Allocation was done by sequentially numbered and opaque sealed envelopes.

Intervention

The participants in the experimental group were given PNF therapy alongside the normal physiotherapy. The PNF therapy was comprised of diagonal patterns of movements for both the upper and lower limbs, rhythmic initiation, repeated contractions, slow reversal, combination of isotonic therapy, and manual resistance with facilitation through verbal and tactile means. Different techniques were used based on the individual restrictions and therapeutic goals.

The control group received only the normal physiotherapy that was comprised of active and passive range of motion exercises, strength training, balance training, transfer training, walking training, task-oriented functional exercises, and postural control exercises.

Outcome Measures

Motor recovery served as the main outcome measure using the Fugl-Meyer Assessment (FMA) for measuring motor impairment and recovery following stroke. Functional independence served as the secondary outcome measure using the Barthel Index (BI). Both

outcome measures were assessed prior to the intervention and immediately following completion of the six-week intervention period.

Data collection and statistical analysis

All data analyses were conducted with the use of SPSS. The descriptive statistics included mean, standard deviation, frequencies, and percentages. Normality of continuous variables was checked prior to the inferential data analyses. Paired-sample t-test was used for the within-group comparison, and independent samples t-test for between-groups comparison of change scores when applicable. In case the normality assumption was not satisfied, non-parametric tests were used. The p value below 0.05 was considered significant. Effect size was calculated as the Cohen's d based on means and SD of change scores.

Results

A total of 40 subjects were involved in the experiment; 20 in each group. The average age in the experimental group was 56.10 ± 9.05 years, while that in the control group was 55.65 ± 8.44 years. The experimental group consisted of 11 males (55.0%) and 9 females (45.0%), while the control group had 10 males (50.0%) and 10 females (50.0%). Right-side stroke occurred in 12 (60.0%) of subjects in the experimental group and 9 (45.0%) of subjects in the control group. Baseline characteristics are summarized in Table 1.

Table 1. Baseline characteristics of participants

Variable	Experimental (n=20)	Control (n=20)
Age, years, mean $\pm$ SD	56.10 ± 9.05	55.65 ± 8.44
Male, n (%)	11 (55.0%)	11 (55.0%)
Female, n (%)	9 (45.0%)	9 (45.0%)
Right-sided stroke, n (%)	12 (60.0%)	9 (45.0%)
Left-sided stroke, n (%)	8 (40.0%)	11 (55.0%)
Months post-stroke, mean $\pm$ SD	3.14 ± 1.21	3.48 ± 1.53

Initially, the mean FMA scores were 41.72 ± 6.43 for the experimental group and 40.84 ± 7.99 for the control group. Post intervention, the mean FMA scores were 52.32 ± 6.97 for the experimental group and 47.37 ± 8.83 for the

control group. The mean increment in the experimental group was 10.60 ± 2.58 and 6.53 ± 2.67 for the control group. The difference in increments between the two groups was statistically significant ($t=4.899$, $p<0.001$)

For functional independence, baseline BI scores for the experimental and control groups were 56.14 ± 9.31 and 58.94 ± 9.43 , respectively. After intervention, scores became 70.48 ± 9.03 and 66.69 ± 10.70 for the two groups, respectively. The mean improvement

for the experimental group was 14.34 ± 5.63 points while that of the control group was 7.76 ± 2.31 points. The change score differed significantly between the two groups ($t=4.842$, $p<0.001$), and there was a large effect size.

Table 2. Pre- and post-intervention outcome scores

Outcome	Experimental Pre	Experimental Post	Control Pre	Control Post	Between-group p-value
FMA	41.72 ± 6.43	52.32 ± 6.97	40.84 ± 7.99	47.37 ± 8.83	<0.001
BI	56.14 ± 9.31	70.48 ± 9.03	58.94 ± 9.43	66.69 ± 10.70	<0.001

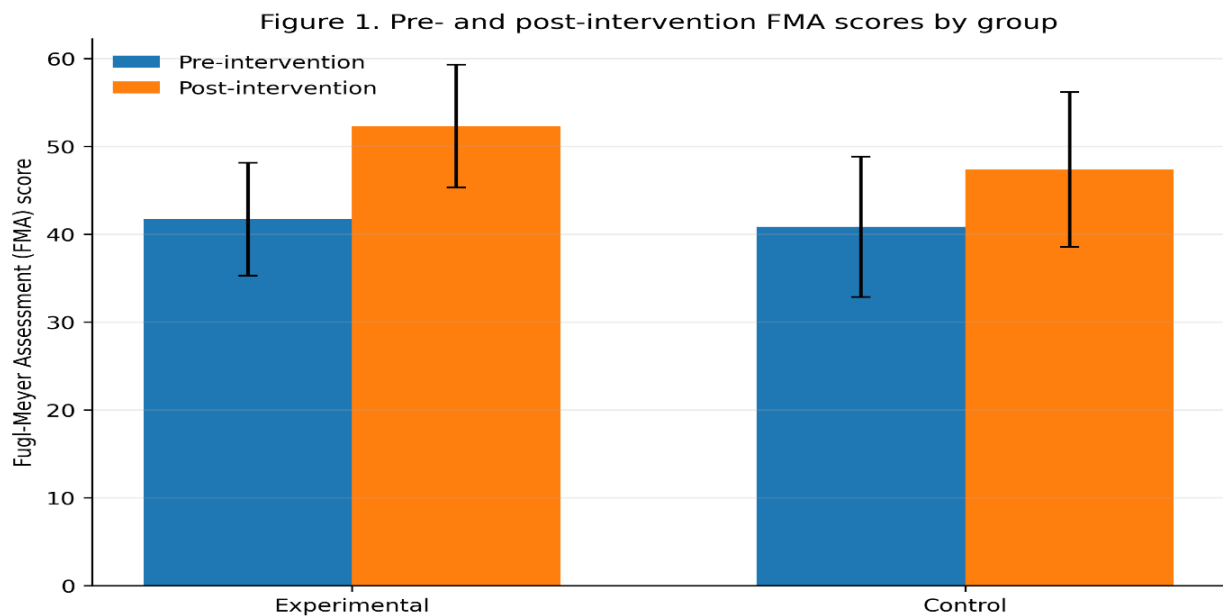


Figure 1. Pre- and post-intervention Fugl-Meyer Assessment scores in the experimental and control groups.

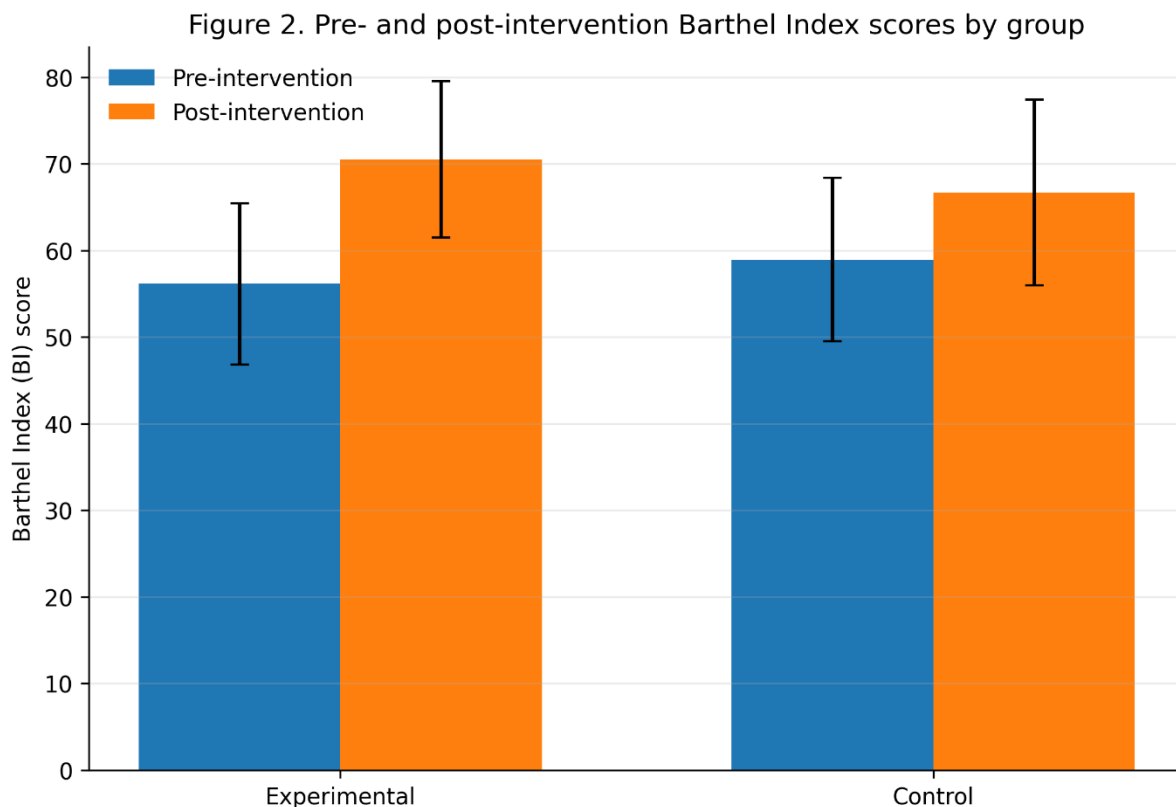


Figure 2. Pre- and post-intervention Barthel Index scores in the experimental and control groups.

Table 3. Between-group comparison of change scores

Outcome	Experimental Change	Control Change	t	p-value
FMA	10.60 ± 2.58	6.53 ± 2.67	4.899	<0.001
BI	14.34 ± 5.63	7.76 ± 2.31	4.842	<0.001

In general, both groups had an improvement in their condition over the six weeks of rehabilitation. But the experimental group which received PNF therapy alongside traditional physiotherapy achieved more significant results compared to the control group, which was undergoing only traditional physiotherapy.

Discussion

The major result of this RCT is that both groups demonstrated progress within six weeks, however, the addition of PNF to the usual physiotherapy was connected with more progress in terms of motor recovery and independent function of patients. Improvement of the experimental group was higher at the FMA scale by 10.60 points, while

the control group showed improvement at 6.53 points. Improvement of the experimental group was higher on BI by 14.34 points, while for the control group this value was 7.76 points. Large effect size is an additional proof of results.

This could be because of the various movement techniques involved in PNF, including proprioceptive inputs, resistance through touch, tactile stimulation, verbal commands, and diagonal movements. All of these have been designed to encourage coordination and neuromuscular control, which is usually hampered in stroke patients. This current research is in line with the earlier research done regarding the positive impact of proprioceptive exercises and PNF-based physiotherapy on motor skills such as balance and gait.

This improved BI score indicates that the possible advantage of the combination therapy was not limited to recovery at the level of impairment but also to functional independence. This clinical significance is because motor skills enhancement does not automatically translate into an improvement in activities of daily living. The greater BI score in the experimental group further strengthens the importance of assessing functional outcome together with impairment-based assessment in stroke patients.

The control group showed significant improvement as well, and this is predictable since the conventional physiotherapy involved a holistic rehabilitation process consisting of range-of-motion exercises, strength training, balance training, transfers, gait, functional activities, and postural control. This proves the point that PNF must be regarded as supplementary to the conventional physiotherapy but not as a replacement. The extra improvement shown by the experimental group reveals that the inclusion of PNF methods in a holistic rehabilitation program may prove advantageous.

A number of issues must be taken into account. First, the sample size was relatively small, and the intervention program was conducted for only six weeks, which makes it hard to generalize the results. Second, only the effects of FMA and BI were evaluated; hence, it is impossible to tell what impact the intervention had on specific variables like walking, balance, participation, or quality of life based on the current study. Third, the methodology used does not provide any precise information about how treatment time was allocated during each training session, progression standards, or blinding of the assessors except for the statement that whenever possible, blinding was applied.

Conclusion

For individuals suffering from stroke, six weeks of conventional physiotherapy along with PNF showed more progress in the areas of motor improvement and functional independence compared to those who were treated with conventional physiotherapy only. While there was improvement for both treatments, the better improvement recorded in terms of the

FMA and BI scores in favor of PNF shows that PNF can be used as an additional treatment in the process of conventional stroke therapy.

REFERENCES

1. Todhunter-Brown A, Sellers CE, Baer GD, Choo PL, Cowie J, Cheyne JD, et al. Physical rehabilitation approaches for the recovery of function and mobility following stroke. *Cochrane Database of Systematic Reviews*. 2025;2:CD001920.
2. Mead GE, Sposato LA, Silva GS, Yperzeele L, Wu S, Kutlubaev M, et al. A systematic review and synthesis of global stroke guidelines on behalf of the World Stroke Organization. *International Journal of Stroke*. 2023;18:499-531.
3. O'Dell MW. Stroke rehabilitation and motor recovery. *Continuum: Lifelong Learning in Neurology*. 2023;29:605-27.
4. European Stroke Organisation Motor Rehabilitation Guideline G. Motor rehabilitation after stroke: European Stroke Organisation consensus-based definition and guiding framework. *European Stroke Journal*. 2023;8:365-77.
5. Lee KE, Choi M, Jeoung B. Effectiveness of Rehabilitation Exercise in Improving Physical Function of Stroke Patients: A Systematic Review. *International Journal of Environmental Research and Public Health*. 2022;19:12739.
6. Lando A, Cacciante L, Mantineo A, Baldan F, Pillastrini P, Turolla A, et al. Multi-Modal versus Uni-Modal Treatment for the Recovery of Lower Limb Motor Function in Patients after Stroke: A Systematic Review with Meta-Analysis. *Healthcare*. 2024;12:189.
7. Huang J, Ji J-R, Liang C, Zhang Y-Z, Sun H-C, Yan Y-H, et al. Effects of physical therapy-based rehabilitation on recovery of upper limb motor function after stroke in adults: a systematic review and meta-analysis of randomized controlled trials. *Annals of Palliative Medicine*. 2022;11:521-31.

8. Chiaramonte R, Bonfiglio M, Leonforte P, Coltraro GL, Guerrera CS, Vecchio M. Proprioceptive and Dual-Task Training: The Key of Stroke Rehabilitation, A Systematic Review. *Journal of Functional Morphology and Kinesiology*. 2022;7:53.
9. Apriliyasari RW, Truong PV, Tsai PS. Effects of proprioceptive training for people with stroke: a meta-analysis of randomized controlled trials. *Clinical Rehabilitation*. 2022;36:431-48.
10. Nguyen PT, Chou L-W, Hsieh Y-L. Proprioceptive Neuromuscular Facilitation-Based Physical Therapy on the Improvement of Balance and Gait in Patients with Chronic Stroke: A Systematic Review and Meta-Analysis. *Life*. 2022;12:882.
11. Zheng K, Li L, Zhou Y, Gong X, Zheng G, Guo L. Optimal proprioceptive training combined with rehabilitation regimen for lower limb dysfunction in stroke patients: a systematic review and network meta-analysis. *Frontiers in neurology*. 2024;15:1503585.
12. Chevalley O, Truijen S, Opsommer E, Saeys W. Physical functioning factors predicting a return home after stroke rehabilitation: a systematic review and meta-analysis. *Clinical Rehabilitation*. 2023;37:1698-716.
13. Triantis E, Liu KPY. Activities of daily living interventions on activity performance of inpatients post-stroke: a systematic review and meta-analysis. *British Journal of Occupational Therapy*. 2024;87:598-613.
14. Kristensen MGH, Busk H, Wienecke T. Neuromuscular Electrical Stimulation Improves Activities of Daily Living Post Stroke: A Systematic Review and Meta-analysis. *Archives of Rehabilitation Research and Clinical Translation*. 2021;4:100167.
15. Everard G, Luc A, Doumas I, Ajana K, Stoquart G, Edwards MG, et al. Self-Rehabilitation for Post-Stroke Motor Function and Activity-A Systematic Review and Meta-Analysis. *Neurorehabilitation and Neural Repair*. 2021;35:1043-58.
16. Nogueira NGdHM, Parma JO, Leão SESdA, Sales IdS, Macedo LC, Galvão ACDR, et al. Mirror therapy in upper limb motor recovery and activities of daily living, and its neural correlates in stroke individuals: A systematic review and meta-analysis. *Brain Research Bulletin*. 2021;177:217-38.
17. Kolmos M, Munoz-Novoa M, Sunnerhagen K, Alt Murphy M, Kruuse C. Upper-extremity motor recovery after stroke: A systematic review and meta-analysis of usual care in trials and observational studies. *Journal of the Neurological Sciences*. 2025;468:123341.