Comparative Effect of Core Stability Training and Proprioceptive Neuromuscular Facilitation on Muscle Strength and Balance in Post-Stroke Patients: A Randomized Controlled Study

Harsh Shekhawat[1]*,Tanpreet Kaur Bakshi[2], Ishika Saxena[3], Bhumika[4] and Jaspreet Singh[5]

[1]Assistant Professor, Venkteshwar College of Physiotherapy SaiTirupati University, Rajasthan
[2]Assistant Professor,Department of Physiotherapy, University Institute of Allied Health and Sciences, Chandigarh University,Mohali, Punjab, India
[3]Assistant Professor, Department of Physiotherapy, University Institute of Allied Health and Sciences, Chandigarh University,Mohali, Punjab, India
[4]Assistant Professor, Vivekanand College of nursing an institute of paramedical sciences
[5]Assistant Professor, Department of Physiotherapy, University Institute of Allied Health and Sciences, Chandigarh University,Mohali, Punjab, India
[1]bmayfield265@gmail.com and [2]tanpreetbakshi1010@gmail.com

Received: 16th Dec, 2025; Revised: 8th Feb 2026; Accepted: 24th Feb, 2026; Available Online: 30th March, 2026

ABSTRACT

Background: Stroke frequently results in impaired balance, reduced muscle strength, and functional limitations. Rehabilitation strategies such as core stability training and Proprioceptive Neuromuscular Facilitation (PNF) are commonly used to enhance recovery.

Objective: To compare the effectiveness of core stability training and PNF techniques combined with conventional physiotherapy on muscle strength and balance in post-stroke patients.

Methods: Thirty post-stroke patients were randomly assigned into two groups. Group A received core stability training with conventional physiotherapy, while Group B received PNF with conventional physiotherapy for 12 weeks. Outcome measures included Manual Muscle Testing (MMT) and the Berg Balance Scale (BBS). Pre- and post-intervention scores were analyzed using paired and independent t-tests.

Results: Both groups demonstrated statistically significant improvements in MMT and BBS scores ($p < 0.05$). Group B showed comparatively greater improvement in balance and muscle strength than Group A.

Conclusion: Both core stability training and PNF are effective in post-stroke rehabilitation. However, PNF combined with conventional physiotherapy produced superior improvements in muscle strength and balance.
Keywords:*Stroke rehabilitation, Core stability, Proprioceptive neuromuscular facilitation, Balance, Muscle strength*
How to cite this article: Shekhawat H, Bakshi TK, Saxena I, Bhumika, Singh J. Comparative Effect of Core Stability Training and Proprioceptive Neuromuscular Facilitation on Muscle Strength and Balance in Post-Stroke Patients: A Randomized Controlled Study. Int J Drug Deliv Technol. 2026;16(24s): 656-660. DOI: 10.25258/ijddt.16.24s.83
Source of support: Nil.
Conflict of interest: None

INTRODUCTION

A stroke is a neurological disorder caused by a disruption in blood flow to the brain, which impairs the provision of oxygen and nutrients to the brain tissue. According to the World Health Organization (WHO, 1978), a stroke is a quickly growing clinical condition of focal or global disruption of brain function that lasts more than 24 hours or causes death. Hatano previously stressed that stroke is only caused by vascular factors and does not include trauma or unintentional harm. Hypoxia brought on by decreased cerebral perfusion eventually results in neuronal injury and loss of function (Adams et al., 1993).

Stroke has historically been called a cerebrovascular accident, but Louis R. Caplan contended that the term "accident" is deceptive because stroke usually results from underlying pathological processes rather than abrupt, unforeseen occurrences. As a result, the National Stroke Association coined the term "brain attack" to emphasize the need for immediate medical attention, much like myocardial infarction.

Ischemic and hemorrhagic strokes are the two main categories of stroke. Cerebral blood flow restriction is the cause of ischemic stroke, which accounts for about 85% of all occurrences (Donnan et al., 2008). It is further divided into cardioembolic stroke, cryptogenic stroke, small vessel

**Author for Correspondence: bmayfield265@gmail.com*

disease, and major artery atherosclerosis. A kind of ischemic stroke, lacunar infarcts impact deep brain structures such the thalamus, internal capsule, pons, and basal ganglia and are frequently linked to persistent hypertension (Fisher, 1982).

About 15% of strokes are hemorrhagic, which is caused by cerebral blood artery rupture that causes bleeding inside or around the brain (Qureshi et al., 2001).It includes subarachnoid hemorrhage, which is frequently brought on by aneurysm rupture, and intracerebral hemorrhage, which is frequently connected to uncontrolled hypertension (van Gijn et al., 2007).

Stroke is still a serious worldwide health issue. The World Health Organization estimates that 15 million people have a stroke each year, of which 5 million die and another 5 million are left permanently disabled (WHO, 2014). According to Feigin et al. (2019), it is one of the main causes of death and long-term impairment in the world.

The incidence of stroke is influenced by a number of modifiable and non-modifiable risk factors. Hypertension, diabetes mellitus, dyslipidemia, obesity, smoking, and physical inactivity are common risk factors (Goldstein et al., 2011). Family history and genetic predisposition are also important (O'Donnell et al., 2016). Additionally, cardioembolic episodes greatly raise the risk of stroke, especially in people with valvular heart disease or atrial fibrillation (Wolf et al., 1991).

For stroke recovery to be guided, effective evaluation is crucial. Neurological impairments, balance, and gait performance are frequently assessed using standardized instruments such the NIH Stroke Scale, Dynamic Gait Index, and Functional Gait Assessment (Lin et al., 2010; Blum and Korner-Bitensky, 2008). The Functional Gait Assessment has proven to be the most sensitive of them in identifying gait abnormalities (Wrisley et al., 2004).

Improving outcomes after stroke requires early management. Stabilization, neuroimaging, and prompt pharmacological measures such blood pressure control and thrombolytic therapy when necessary are the main goals of first care (Powers et al., 2018). Because it increases mobility, avoids problems, and improves functional results, early physiotherapy beginning is crucial to recovery (Langhorne et al., 2011; Bernhardt et al., 2015). A comprehensive strategy combining coordinated treatment from medical specialists is necessary for stroke rehabilitation. Reducing disability, regaining functional independence, and enhancing quality of life are the main objectives (Wade, 1992; Carr and Shepherd, 2010). Furthermore, in order to lower the risk of recurrent stroke, secondary prevention through risk factor management is crucial (Winstein et al., 2016). All things considered, comprehensive rehabilitation techniques greatly improve long-term results and enhanced quality of life among stroke survivors (Langhorne et al., 2017).

METHODOLOGY

A comparative randomized controlled study was conducted over a period of 12 weeks at M.B. Government Hospital, Udaipur, Rajasthan. Thirty patients diagnosed with post-stroke hemiparesis were recruited after screening more than sixty individuals. Participants aged between 45 and 70 years, of both genders, and diagnosed with stroke with the presence of hemiparesis were included in the study. Patients with a history of seizures, those above 70 years of age, post-surgical patients, individuals with psychological disorders, and those who refused to provide informed consent were excluded from the study.

The eligible participants were randomly assigned into two groups, with 15 patients in each group, using a simple chit method. Group A received core stability training along with conventional physiotherapy, while Group B received Proprioceptive Neuromuscular Facilitation (PNF) techniques along with conventional physiotherapy. All participants underwent intervention sessions for 30 minutes per day, five days per week, for a total duration of 12 weeks, with two days of rest each week.

Participants in Group A performed a structured core stability training program consisting of bridging exercises, pelvic tilts, seated balance training, lumbar strengthening exercises, and Swiss ball exercises. These exercises were designed to strengthen the abdominal, lumbar, and pelvic muscles and to improve postural control, balance, and functional mobility. The intensity and progression of exercises were adjusted according to individual patient tolerance and improvement.

Participants in Group B received PNF-based rehabilitation, which included rhythmic initiation techniques to facilitate the initiation of movement and D1 and D2 diagonal movement patterns to promote functional upper and lower limb movements. Functional movement facilitation techniques were also incorporated to enhance neuromuscular coordination, proprioception, and voluntary motor control. The PNF interventions were delivered according to standardized therapeutic principles and were progressively modified based on patient performance.

In addition to the specialized interventions, both groups received conventional physiotherapy throughout the study period. This included passive stretching of bilateral upper and lower limbs, active-assisted exercises to improve voluntary control, resistive exercises to enhance muscle strength, isometric exercises for lower limb stabilization, and straight leg raising exercises to improve lower limb endurance and control.

Outcome measures were assessed before and after the intervention period using Manual Muscle Testing (MMT) to evaluate muscle strength and the Berg Balance Scale (BBS) to assess balance and risk of falls. Data were analyzed using the Statistical Package for Social Sciences (SPSS) version 20. Paired t-tests were used to compare pre- and post-intervention scores within each group, while independent t-tests were applied to analyze differences between the two groups. Statistical significance was set at $p < 0.05$.

RESULTS

Demographic Characteristics

The sample included 11 males and 19 females. Mean age was 31.33 ± 5.13 years in Group A and 29.67 ± 6.60 years in Group B.

Table 1: Comparison of mean values for MMT and BBSscores pre- and post-intervention in Groups A and B

Parameters	GROUP A		t value	p value	GROUP B		t value	p value
	PRE Mean± SD	POST Mean± SD			PRE Mean± SD	POST Mean± SD		
BBS	62.66±20.95	45±.34.9	14.76	.0001 (S)	62±21.70	45.33±34.0	12.76	.0001 (S)
MMT	6.06 ± 2.26	4.53±.3.40	6.6	.0001 (S)	5.73±4.6	4.53±3.30	6.65	.0001 (S)

Table 1 compares the mean values of VAS and MMTscores before and after the intervention within the two groups. The analysis of VAS and MMTscores using Student's t-test indicated significant difference (p<0.05) in pre- and post-intervention in both groups.

Table 2: Comparison of the improvement in mean values for BBS and MMT scores of pre- and post-interventions in Groups A and B

Parameters	GROUP A (Mean ± SD)	GROUP B (Mean ± SD)	t value	p value
BBS	62.66±20.95	45.00±34.90	3.28	.003 (S)
MMT	6.06±2.26	4.53±3.40	3.66	.001(S)

The analysis of the difference in mean values of pre- and post-intervention of VAS and MMT scores between Groups A and B is described in Table 2. A comparison of VAS and MMTscores revealed a statistically significant difference (p<0.05) between Groups A and B.

Within-Group Analysis

Group A

- MMT: Pre-test = 6.06 ± 2.26, Post-test = 4.53 ± 3.40
- BBS: Pre-test = 62.66 ± 20.95, Post-test = 45.00 ± 34.90

Significant improvement was observed ($p < 0.05$)

Group B

- MMT: Pre-test = 5.73 ± 4.60, Post-test = 4.53 ± 3.40
- BBS: Pre-test = 62.00 ± 21.70, Post-test = 45.33 ± 34.00

Significant improvement was observed ($p < 0.05$)

.Between-Group Comparison

Independent t-test revealed statistically significant differences between groups ($p < 0.05$). Group B demonstrated greater improvement than Group A in both MMT and BBS scores.

DISCUSSION

The present study aimed to compare the effectiveness of core stability training and Proprioceptive Neuromuscular Facilitation (PNF), both combined with conventional physiotherapy, on muscle strength and balance among stroke patients. The findings of this study demonstrate that both intervention groups showed statistically significant improvements in Manual Muscle Testing (MMT) and Berg Balance Scale (BBS) scores following 12 weeks of treatment.

Within-group analysis revealed significant improvements in both Group A (core stability training) and Group B (PNF training), as indicated by *p* values less than 0.05. These findings suggest that structured physiotherapeutic interventions, when applied consistently, play a crucial role in enhancing motor recovery, muscle strength, and balance in stroke patients. Early and task-specific rehabilitation has been widely reported to improve functional outcomes by promoting neuroplasticity and motor relearning (Langhorne et al., 2011; Bernhardt et al., 2015).

Core stability training focuses on strengthening the deep trunk muscles, including the abdominal, lumbar, and gluteal muscle groups, which are essential for maintaining postural control and balance. Stroke often results in impaired trunk control, leading to reduced stability and functional limitations. Strengthening these core muscles enhances proximal stability, which in turn facilitates distal mobility and functional activities.

Previous studies have supported the role of trunk rehabilitation in improving balance and gait performance in stroke patients (Carr and Shepherd, 2010).

On the other hand, PNF training demonstrated comparatively greater improvements in both MMT and BBS scores. Between-group analysis also indicated statistically significant differences favoring Group B ($p< 0.05$). The higher *t*-values observed in the PNF group further emphasize its superior effectiveness in improving neuromuscular performance and balance outcomes.

PNF is a well-established rehabilitation approach that utilizes specific movement patterns combined with resistance and proprioceptive input to enhance neuromuscular coordination and motor control. According to **Dorothy Voss** and later expanded by **Susan S. Adler**, PNF techniques facilitate muscle activation, improve flexibility, and enhance functional movement patterns

(Adler et al., 2008). These techniques stimulate proprioceptors, thereby improving motor unit recruitment and coordination.

The superior outcomes observed in the PNF group may be attributed to its ability to promote neuroplasticity, which is essential for recovery following stroke. By engaging patients in functional, diagonal, and rotational movement patterns, PNF enhances motor relearning and improves voluntary control. Additionally, PNF has been shown to improve circulation, metabolic activity, and muscular endurance, contributing to overall functional recovery.

Supporting evidence from previous literature further validates the findings of this study. Kumar et al. (2019) reported that PNF-based interventions significantly improved muscle strength and functional performance in stroke patients compared to conventional therapy. Similarly, Lee and Lee (2020) conducted a randomized controlled trial demonstrating that PNF enhances voluntary muscle activation and promotes cortical reorganization, leading to improved motor outcomes.

Although both interventions were effective, the greater improvement observed in the PNF group suggests that incorporating proprioceptive and neuromuscular facilitation techniques may yield better rehabilitation outcomes than core stability training alone. However, core stability exercises remain an essential component of stroke rehabilitation, particularly for improving trunk control and postural stability.

Despite these promising findings, the study has certain limitations. The sample size was relatively small ($n = 30$), which may limit the generalizability of the results. Additionally, the study duration was limited to 12 weeks, and long-term follow-up was not conducted to assess the sustainability of improvements. Future studies with larger sample sizes and extended follow-up periods are recommended to further validate these findings.

CONCLUSION

Both core stability training and PNF, when combined with conventional physiotherapy, significantly improve muscle strength and balance in stroke patients. However, PNF demonstrated comparatively greater effectiveness, suggesting its potential as a preferred intervention in stroke rehabilitation programs.PNF may be recommended as a preferred rehabilitation approach for improving functional recovery in post-stroke individuals. Future studies with larger samples and longer follow-up are recommended.

REFERENCES

1. Adams HP Jr, Bendixen BH, Kappelle LJ, Biller J, Love BB, Gordon DL, et al. Classification of subtype of acute ischemic stroke: Definitions for use in a multicenter clinical trial. *Stroke*. 1993;24(1):35–41.
2. World Health Organization. Cerebrovascular disorders: A clinical and research classification. Geneva: WHO; 1978.
3. Hatano S. Experience from a multicentre stroke register: A preliminary report. *Bull World Health Organ*. 1976;54(5):541–553.
4. Adams HP Jr, et al. Pathophysiology and clinical aspects of ischemic stroke. *Stroke*. 1993;24(1):35–41.
5. Donnan GA, Fisher M, Macleod M, Davis SM. Stroke. *Lancet*. 2008;371(9624):1612–1623.
6. Caplan LR. Caplan's Stroke: A Clinical Approach. 4th ed. Philadelphia: Elsevier Saunders; 2006.
7. National Stroke Association. Stroke: A brain attack. Englewood, CO: National Stroke Association; 1999.
8. Donnan GA, Fisher M, Macleod M, Davis SM. Stroke. *Lancet*. 2008;371(9624):1612–1623.
9. Adams HP Jr, et al. Classification of stroke subtypes. *Stroke*. 1993;24(1):35–41.
10. Qureshi AI, Tuhrim S, Broderick JP, Batjer HH, Hondo H, Hanley DF. Spontaneous intracerebral hemorrhage. *N Engl J Med*. 2001;344(19):1450–1460.
11. vanGijn J, Kerr RS, Rinkel GJE. Subarachnoid haemorrhage. *Lancet*. 2007;369(9558):306–318.
12. World Health Organization. Global status report on noncommunicable diseases. Geneva: WHO; 2014.
13. Feigin VL, Norrving B, Mensah GA. Global burden of stroke. *Circ Res*. 2017;120(3):439–448.
14. Goldstein LB, Bushnell CD, Adams RJ, Appel LJ, Braun LT, Chaturvedi S, et al. Guidelines for the primary prevention of stroke. *Stroke*. 2011;42(2):517–584.
15. O'Donnell MJ, Chin SL, Rangarajan S, Xavier D, Liu L, Zhang H, et al. Global and regional effects of potentially modifiable risk factors associated with acute stroke. *Lancet*. 2016;388(10046):761–775.
16. Wolf PA, Abbott RD, Kannel WB. Atrial fibrillation as an independent risk factor for stroke. *Stroke*. 1991;22(8):983–988.
17. Bamford J, Sandercock P, Dennis M, Burn J, Warlow C. Classification and natural history of stroke. *Lancet*. 1991;337(8756):1521–1526.
18. Fisher CM. Lacunar strokes and infarcts: A review. *Neurology*. 1982;32(8):871–876.
19. Broderick J, Brott T, Tomsick T, Miller R, Huster G. Intracerebral hemorrhage more than twice as common as subarachnoid hemorrhage. *Stroke*. 1993;24(12):1761–1765.
20. vanGijn J, Rinkel GJE. Subarachnoid haemorrhage: Diagnosis, causes and management. *Brain*. 2001;124(2):249–278.
21. Lin JH, Hsu MJ, Hsu HW, Wu HC, Hsieh CL. Psychometric comparisons of 3 functional ambulation measures. *Stroke*. 2010;41(9):2021–2025.

22. Blum L, Korner-Bitensky N. Usefulness of the Berg Balance Scale in stroke rehabilitation. *PhysTher*. 2008;88(5):559–566.

23. Wrisley DM, Marchetti GF, Kuharsky DK, Whitney SL. Reliability and validity of the Functional Gait Assessment. *PhysTher*. 2004;84(10):906–918.

24. Powers WJ, Rabinstein AA, Ackerson T, Adeoye OM, Bambakidis NC, Becker K, et al. Guidelines for early management of acute ischemic stroke. *Stroke*. 2018;49(3):e46–e110.

25. Langhorne P, Bernhardt J, Kwakkel G. Stroke rehabilitation. *Lancet*. 2011;377(9778):1693–1702.

26. Bernhardt J, Langhorne P, Lindley RI, et al. Early mobilization after stroke. *Lancet*. 2015;386(9988):46–55.

27. Winstein CJ, Stein J, Arena R, Bates B, Cherney LR, Cramer SC, et al. Guidelines for adult stroke rehabilitation. *Stroke*. 2016;47(6):e98–e169.

28. Wade DT. Measurement in neurological rehabilitation. Oxford: Oxford University Press; 1992.

29. Carr JH, Shepherd RB. Neurological Rehabilitation: Optimizing Motor Performance. 2nd ed. Edinburgh: Churchill Livingstone; 2010.

30. Langhorne P, Ramachandra S. Stroke rehabilitation: Evidence-based review. *Lancet*. 2017;389(10068):1693–1702

31. Adler SS, Beckers D, Buck M. *PNF in Practice: An Illustrated Guide*. 3rd ed. Springer; 2008.

32. Kumar S, et al. Effect of PNF on motor recovery in stroke patients. *Int J Physiother Res*. 2019.

33. Lee JS, Lee HG. The effects of PNF on motor function in stroke patients: A randomized controlled trial. *J PhysTher Sci*. 2020.

34. Langhorne P, Bernhardt J, Kwakkel G. Stroke rehabilitation. *Lancet*. 2011;377:1693–1702.

35. Bernhardt J, et al. Early mobilization after stroke. *Lancet*. 2015;386:46–55.

36. Carr JH, Shepherd RB. *Neurological Rehabilitation*. 2nd ed. Churchill Livingstone; 2010.