

Effect of Proprioceptive Neuromuscular Facilitation Technique on Balance in Stroke Patients: A Narrative Review

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ABSTRACT

Stroke, or Cerebrovascular Accident (CVA), is a condition that impairs the brain by rupturing blood vessels or by obstructing blood arteries with blood clots, causing a significant deterioration in the patient's functioning and worsening their Quality of Life (QOL). Stroke patients are prone to falls and fall-related complications after a stroke, which are associated with balance disorders leading to activity limitations, increased dependency, affecting social and community participation, QOL, longer treatment duration, and slow prognosis. Balance disorders and fall risks after a stroke hinder stroke rehabilitation, so it is essential to improve balance for better results in stroke rehabilitation. Over the last decade, the Proprioceptive Neuromuscular Facilitation (PNF) technique has shown potential for improving balance in stroke patients. A systematic literature search was conducted, and the findings were critically reviewed and thematically analysed.

Keywords: Cerebrovascular accident, Proprioceptive neuromuscular facilitation, Quality of life, Stroke rehabilitation

INTRODUCTION

Stroke is defined by the World Health Organisation (WHO) as “rapidly emerging clinical signs of localised disruption of brain activity, with symptoms persisting for 24 hours or more, or leading to fatal consequences, with no evident explanation other than of vascular origin” [1]. A stroke is a condition that impairs the brain by rupturing the blood vessels that supply oxygen and nutrients, or by obstructing the blood arteries with blood clots [2]. As a result of these occurrences, various parts of the body may experience weakness, reduced sensitivity, limited movement, and coordination issues, resulting in speech abnormalities, loss of control of anal and visceral sphincters, vision disturbances, and impaired balance or coordination [3]. The trunk is considered a central key point enabling the body to stay upright and adjust weight shifts during static and dynamic postural changes. Following a stroke, one side of the limbs is affected, but trunk muscles are impacted on both sides, leading to inadequate trunk rotation, difficulties in maintaining balance and gait [4]. Balance is defined as an individual's ability to keep the centre of gravity within a specific region, thereby maintaining a balanced body state [5]. As postinjury symptoms, stroke patients encounter challenges with balance and postural adjustments. Due to asymmetric posture and decreased body balance and weight-shifting ability, their postural sway increases, and the centre of gravity shifts to the non paretic lower limb [6]. The ability to balance is crucial for hemiplegic patients who have suffered a stroke, and its improvement is a primary goal for both patients and their family members [7]. Various approaches, such as functional methods, neurodevelopmental treatments for motion control, Proprioceptive Neuromuscular Facilitation (PNF) utilising diagonal movement patterns, and dual-task training, are employed to enhance the balance and gait of stroke patients [8]. PNF enhances muscle and tendon functions by stimulating the proprioceptive sense, thereby improving muscle strength, flexibility, and balance [9]. Stroke patients are susceptible to falls and associated complications, including fractures, decreased confidence and mobility, and longer rehabilitation periods. Studies suggest that cognition and balance are significant risk factors for falls, often inadequately addressed in clinical practice [10]. Balance disorders, fall risks, and fear of falling

post-stroke hinder rehabilitation efforts, making it imperative to improve balance through rehabilitation programmes incorporating balance training, muscle strengthening, and flexibility training. Such programmes effectively enhance gait, balance, and the perception of falling among stroke patients [11]. Over the past decade, the PNF technique has been increasingly utilised to improve motor function, muscular strength, flexibility, coordination, and balance in stroke patients, showing consistent enhancements across various studies. Integrating the PNF technique more extensively into therapeutic regimens for stroke patients can lead to reduced fall-related complications, shorter treatment durations, decreased dependency, improved prognosis, and enhanced social and community participation. The aim of this review is to assess the effectiveness of the PNF technique on balance in stroke patients, either individually or in combination with other treatment modalities.

MATERIALS AND METHODS

Search strategy: To gain a comprehensive understanding of the effect of the PNF technique on balance in stroke patients, a systematic search of peer-reviewed articles published after 2013 was conducted. Databases such as PubMed, Scopus, Web of Science, and Google Scholar were utilised, employing medical subject headings terms and free-text keywords like PNF, stroke, CVA, and balance. From the 90 articles identified, 25 were selected based on inclusion and exclusion criteria and reviewed in-depth.

Inclusion criteria:

- Articles published between 2013 and 2023.
- Studies that evaluated the effect of the PNF technique on balance in stroke patients.
- Randomised Controlled Trials (RCTs), cohort studies, meta-analyses and systematic reviews.
- Articles published in the English language.

Exclusion criteria:

- Articles not directly related to the effect of PNF on balance in stroke patients.
- Non English articles.

An Overall Review of Proprioceptive Neuromuscular Facilitation (PNF) Technique

The PNF is a technique historically used to restore muscular function, coordination, balance, and joint mobility. In a study by Kim K et al., coordination movements using the PNF pattern efficiently work on the paralysed side muscles, improving posture and balance, consequently enhancing walking ability. PNF emerges as a suitable therapy method for stroke patients facing gait issues due to decreased weight support and balancing ability [8]. Asghar M et al., suggested that incorporating PNF into the routine treatment of stroke survivors enhances balancing capabilities. PNF, rooted in motor development and neuroplasticity concepts, elevates Brain-derived Neurotrophic Factor (BDNF) levels, aiding in brain tissue repair and enhancing the functional capabilities of post-stroke patients [12]. In a systematic review by Yan-Fei Li, existing literature indicates that PNF techniques significantly enhance balance and mobility in stroke patients. However, there is limited evidence of its superiority over other rehabilitation techniques or conventional training methods [13]. Vaidya A, in his study on PNF, concluded that PNF is more effective for improving gait and balance post-acute stroke, measuring gait with the Dynamic Gait Index (DGI) and balance with the Berg Balance Scale (BBS) [14]. Chaturvedi P et al., concluded that PNF exercises are specialised and standardised exercises involving the neck, trunk, scapula, upper and lower extremities, along with audiovisual cues, distinguishing them from other exercises. PNF may have positive effects on functional outcomes by enhancing neuroplasticity. PNF exercises can be implemented from the first day, even in moderate to severe strokes [15].

Comparing PNF with other therapeutic techniques, PNF often proves superior or at least equally effective in enhancing post-stroke balance. Several studies reported that both PNF and traditional therapy improved balance, yet the PNF group showed quicker progress. While PNF as a standalone intervention shows promise, combining it with other rehabilitation strategies, such as Virtual Reality (VR) or mirror therapy, could offer an exciting avenue for potential synergistic effects. This could be attributed to providing multimodal sensory feedback, enhancing neuromuscular re-education, and balance. In a comparative study, dos Santos Junior VA et al., compared different treatment strategies (PNF, VR, or PNF/VR) for improving sensorimotor function recovery after a stroke and observed motor function improvement in the upper limb across all groups. They noted improvement in the motor function of the lower limb in the VR group and in balance in the PNF and PNF/VR groups. They believe this improvement may be linked to the strengthening of the proximal musculature promoted by PNF exercises, where pelvic and scapula diagonal exercises aid in stabilising the trunk [16]. Additionally, the potential of PNF in reducing fall risk among stroke patients is particularly noteworthy. Post-stroke falls are common and can lead to further complications, including fractures, decreased confidence and mobility, and extended rehabilitation duration. By enhancing static and dynamic balance, PNF not only contributes to functional recovery but also enhances the safety and confidence of stroke survivors, reducing treatment duration. Cayco CS et al., in a study, demonstrated that a PNF programme coupled with principles of neuroplasticity is safe and effective in improving motor outcomes, showing positive effects on balance, strength, mobility, and reducing fall risk in older individuals with chronic stroke [17]. A number of studies have shown that PNF techniques significantly enhance postural stability in stroke patients. Patients undergoing PNF training

exhibited improved static and dynamic balance scores compared to those who did not. In addition to balance, functional mobility is crucial for daily activities, and PNF has been shown to improve functional mobility, closely correlating with balance improvements. In a meta-analysis, Shinde K and Ganvir S observed that trunk PNF patterns are effective in enhancing trunk control in stroke patients, with post-treatment results indicating improvements in static and dynamic sitting balance and coordination as assessed by the Trunk Impairment Scale [18]. The specific PNF patterns that have shown effectiveness, such as the spiral and diagonal techniques, deserve special attention because the biomechanical rationale behind these patterns mimics functional movements, potentially leading to better neuromuscular coordination and re-learning. The repetition of functional movement patterns can significantly facilitate the journey back to daily independence for many stroke survivors. Kim CH and Kim YN established that symmetrical reciprocal combined scapular and pelvic PNF patterns are effective for improving motor control in the gait pattern [19]. In a study, Lee DK and Hwang TY concluded that aquatic PNF patterns effectively improved balance, gait ability, and depression in patients with chronic stroke [20]. Lim CG demonstrated in his study that PNF pattern exercises using sprinter and skater techniques may enhance balance and gait function in stroke patients [21]. Kang TW and Kim BR conducted a study, and the results suggested that the chopping pattern of PNF is effective in improving hemispatial neglect, enhancing balance, and activities of daily living in stroke patients [22]. A key takeaway from the review is the flexibility of PNF across different stages of post-stroke rehabilitation. The adaptability of PNF, evidenced by its effectiveness in both acute and chronic post-stroke phases, marks it as an essential tool for therapists. This flexibility is significant given the variability in recovery trajectories among stroke patients; some patients may show rapid improvement while others may require longer periods. In a systematic review with meta-analysis, Nguyen PT et al., suggested that PNF-based physical therapy has statistically significant effects on improving balance and gait speed at least six months post-stroke. For trunk control at the chronic stage in stroke patients, utilising PNF pelvic, neck, sprinter, and skater patterns in various positions with isotonic, dynamic reversal, stretching, reversal stabilisation, or resisted techniques can offer a strategy for implementing clinical practice for balance and gait functions [23]. Jeong WM et al., in a study, applied PNF lower leg taping and treadmill training to patients with hemiplegia resulting from a stroke, concluding that taping and treadmill training based on the PNF concept are considered useful programmes for improving gait and balance abilities in hemiplegic patients [24]. Pachruddin I et al., concluded in a study that PNF focuses on movement with diagonal and spiral patterns congruent with movements used in daily activities. PNF exercises influence standing balance ability in post-stroke patients, and physiotherapists in hospitals or clinics can select PNF exercises as a modality to enhance standing balance ability in post-stroke patients [25]. Shirsath AH et al., in a study, stated that the rhythmic stabilisation technique of PNF significantly improves strength, endurance, flexibility, stability, balance, as well as functional performance in stroke patients [26]. The evidence presented in the last decade emphasises the potential of PNF in restoring balance in stroke rehabilitation [27]. However, limited studies have been completed that demonstrate the definite treatment protocol and long-term effects of PNF techniques on balance in stroke patients. Therefore, long-term effects are an area that requires further evaluation. A summary has been provided in [Table/Fig-1]

S. No.	Author name	Title of the study	Intervention	Finding
1.	Thorawade S and Solankhi C [2] (2023)	Effect of eye movement with PNF neck movement on balance and functional mobility in subacute stroke patients	Proprioceptive Neuromuscular Facilitation (PNF)	The study shows that eye movement and neck movement by PNF found to be beneficial for improving balance and functional mobility among subacute stroke patients.
2.	Boob MA and Kovela RK [1] (2022)	Effectiveness of pelvic Proprioceptive Neuromuscular Facilitation (PNF) techniques on balance and gait parameters in chronic stroke patients: A randomised clinical trial	Pelvic PNF along with task-oriented exercises	The study shows that pelvic PNF along with task-oriented exercises proved to be beneficial and can help in the restoration of balance and gait parameters in stroke patients.

3.	Yan-Fei Li [13] (2022)	Effectiveness of Proprioceptive Neuromuscular Facilitation (PNF) techniques in improving balance in poststroke patients: A systematic review	Proprioceptive Neuromuscular Facilitation (PNF)	The study found that PNF techniques effectively improve balance and mobility in stroke patients.
4.	Nguyen PT et al., [23] (2022)	PNF- based physical therapy on the improvement of balance and gait in patients with chronic stroke: A systematic review and meta-analysis	PNF	This review indicates that PNF is a potential treatment strategy in chronic stroke rehabilitation for improving balance and gait speed.
5.	Dinesh M et al., [3] (2022)	PNF neck pattern and trunk specific exercise on trunk control and balance — an experimental study	PNF neck pattern and trunk-specific exercise	The study shows that PNF neck pattern and trunk-specific exercise effectively improved balance and trunk control among patients with stroke.
6.	Hazarika S et al., [27] (2022)	Comparison of effectiveness of trunk PNF versus Neurodevelopmental Treatment (NDT) on trunk stability in stroke patients	Trunk PNF vs NDT	The study found that trunk PNF technique with conventional exercises is more effective than NDT for improving the trunk stability in acute or sub-acute stroke patients.
7.	Asghar M et al., [12] (2021)	Effectiveness of PNF on balance in chronic stroke patients	PNF	The study found that PNF along with routine physical therapy was more effective in improving balance in stroke patients as compared to routine physical therapy alone.
8.	Vaidya A [14] (2020)	Comparison between PNF versus mirror therapy enhances gait and balance in paretic lower limb after acute stroke	PNF vs Mirror therapy	The study shows that PNF is more effective for enhancing gait and balance in paretic lower limb after acute stroke.
9.	Pachruddin I et al., [25] (2019)	Effect of PNF on standing balance control among poststroke patients	PNF	The study shows influenced of PNF exercises toward the standing balance ability in poststroke patients and physiotherapist in the hospital or clinic can choose the PNF exercise as one modality to improve the standing balance ability of poststroke patients.
10.	Kang TW and Kim BR [22] (2019)	Effect of PNF chopping pattern on neglect, balance, and activity of daily living of stroke patients with hemi-spatial neglect: A randomised clinical trial	PNF	These study results suggest that the chopping pattern of PNF is effective in improving the hemi-spatial neglect, balance, and activities of daily living in stroke patients.
11.	Lee DK and Hwang TY [20] (2019)	Effects of aquatic PNF pattern exercise on balance, gait ability and depression in patients with chronic stroke	PNF	The study suggests that the aquatic PNF pattern exercise effectively improved the balance, gait ability and depression in patients with chronic stroke.
12.	Cayco CS et al., [17] (2019)	PNF to improve motor outcomes in older adults with chronic stroke	PNF	The study shows the positive outcomes in balance, strength, and mobility in all cases and PNF can modify motor outcomes to decrease fall risk in older people with chronic stroke.
13.	dos Santos Junior VA et al., [16] (2019)	Combining PNF and Virtual Reality (VR) for Improving Sensorimotor Function in Stroke Survivors: A Randomised Clinical Trial	PNF and VR	The study shows significant improvement in the passive movement and pain score in the PNF and PNF/VR groups and the same was observed for the motor function of the upper limb as well as the motor function of the lower limb in the VR group and for balance in the PNF and PNF/VR groups.
14.	Shirsath AH et al., [26] (2019)	Effect of PNF technique for knee and ankle muscles on lower limb performance in subacute stroke	PNF	The study emphasised a potential role of rhythmic stabilisation showing an effective method for improving balance and walking ability in subacute stroke patients.
15.	Chaturvedi P et al., [15] (2018)	PNF vs. task specific training in acute stroke: the effects on neuroplasticity	Proprioceptive Neuromuscular Facilitation (PNF) vs. task specific training	The study suggests that the PNF exercises may effective in promoting neuroplasticity and functional activities.
16.	Kim CH and Kim YN [19] (2018)	Effects of PNF and treadmill training on the balance and walking ability of stroke patients	PNF and treadmill training	The study suggests the combined training using PNF techniques and treadmills may be useful in improving the balance and walking ability of stroke patients.
17.	Sharma V and Kaur J [4] (2017)	Effect of core strengthening with pelvic PNF on trunk, balance, gait, and function in chronic stroke	Core strengthening with pelvic PNF	The study results indicated that core stabilisation combined with pelvic PNF was more effective for improving trunk impairment, balance and gait of chronic stroke patients.
18.	Jeong WM et al., [24] (2016)	Effect of treadmill training and PNF lower leg taping on balance and gait ability in stroke patients	Treadmill training and PNF	This study applied PNF lower leg taping and treadmill training to patients with hemiplegia resulting from a stroke, and this resulted in improvement in gait and balance abilities.
19.	Hwangbo PN and Kim KD [9] (2016)	Effects of PNF neck pattern exercise on the ability to control the trunk and maintain balance in chronic stroke patients	PNF	The study found that PNF neck pattern exercise has a positive effect on increasing the ability to control the trunk and maintain balance in chronic stroke patients.
20.	Kim EK et al., [5] (2015)	Effects of aquatic PNF lower extremity patterns on balance and ADL of stroke patients	Aquatic PNF	The study results indicate that performing aquatic PNF patterns in the lower extremity enhances balance and ADL in stroke patients.
21.	Seo KC et al., [6] (2015)	The effects of stair gait training using PNF on stroke patients' dynamic balance ability	PNF	The study suggests that gait training group to which PNF was applied saw improvements in their balance ability.
22.	Seo KC and Kim HA [7] (2015)	The effects of ramp gait exercise with PNF on stroke patients' dynamic balance	Ramp gait exercise with PNF	The study shows that ramp gait training with PNF improved stroke patients' dynamic balance ability.
23.	Kim K et al., [8] (2015)	Effect of coordination movement using the PNF pattern underwater on the balance and gait of stroke patients	PNF	The study demonstrates that coordination movement using the PNF pattern under water has a significant effect on the balance and gait of stroke patients.
24.	Shinde K and Ganvir S [18] (2014)	Effectiveness of trunk PNF techniques after stroke: A metaanalysis	Trunk PNF	This meta-analysis shows that stroke survivors may benefit from trunk PNF technique during acute and sub-acute stages to improve trunk control and balance.
25.	Lim CG [21] (2014)	The effects of PNF pattern exercise using the sprinter and the skater on balance and gait function in the stroke patients	PNF	This study suggests that PNF pattern exercise using sprinter and skater may be used to improve balance and gait function in stroke patients.

[Table/Fig-1]: Summary of past literature [1-9,12-20,22-27].

[1-9,12-20,22-27]. Despite the significantly positive evidence from this study, it is crucial to acknowledge the methodological conflicts present across the studies, as these differences can impact results and interpretations. Larger, more standardised trials would provide clearer insights into the true extent of PNF's benefits.

CONCLUSION(S)

The PNF technique consistently illustrated positive effects on improving balance in stroke patients. Numerous studies emphasised that the PNF technique, when compared to conventional rehabilitation exercises, showed significant improvements in static and dynamic balance, functional mobility, and overall quality of life. However, the degree of improvement varied across studies and depended on various factors such as the severity of the stroke, the duration and frequency of PNF interventions, and the specific PNF patterns applied. Future investigations should aim for greater standardisation, explore long-term outcomes, and establish PNF's position relative to other rehabilitation strategies.

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