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Research Paper

Effectiveness of proprioceptive neuromuscular facilitation technique on balance and mobility in chronic stroke patient

Shreyash A. Manapure*
*Department of Pharmacology, Dr. Rajendra Gode Institute of Pharmacy, Amravati, India.

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ABSTRACT

This comprehensive review explores the multifaceted impact of stroke, a cerebrovascular disorder, on individuals, emphasizing the physical, emotional, and cognitive dimensions of its aftermath. Stroke is a major global health concern, contributing significantly to mortality and disability. The immediate consequences involve neurological impairments such as paralysis, speech difficulties, and impaired vision, while the emotional toll includes coping with loss and adjusting to new realities. Long-term cognitive implications affect memory, attention, and executive function, adding complexity to the recovery journey. Communication challenges, physical limitations, and the risk of secondary complications are discussed, highlighting the importance of a continuum of care. The role of caregivers is explored, emphasizing the emotional, physical, and financial burdens they face. Technological innovations, such as virtual reality and robotics, are introduced as promising tools in stroke rehabilitation. The focus then shifts to balance and mobility issues in stroke survivors, particularly the impact of proprioceptive neuromuscular facilitation (PNF) techniques. Proprioceptive neuromuscular facilitation emerges as a dynamic and versatile therapeutic approach, offering promise for improved functional outcomes and enhanced quality of life in the evolving landscape of stroke care and rehabilitation. The review delves into the neurophysiological ballet of PNF, emphasizing neuromuscular stimulation, neuroplasticity, and motor learning. Clinical applications of PNF in orthopaedic, neurological, geriatric, and paediatric rehabilitation are discussed, highlighting its versatility.

Corresponding Author:
Shreyash A. Manapure
Department of Pharmacology, Dr. Rajendra Gode Institute of Pharmacy, Amravati, India.
Email: shreyashmanapure6@gmail.com

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1. INTRODUCTION

Stroke is a cerebrovascular disorder (CVD) and one of the leading cause for mortality and disability. According to World Health Organization annually 15 million people suffer from stroke worldwide and according to the Indian Stroke Association (ISA) 1.8 million people suffer a stroke each year, with 59% mortality. Stroke is the 4th leading cause of death and 5th leading cause for disability in India [1]. About 87% of all strokes are ischemic strokes, it is a neurological disorder in which blood flow to brain is blocked. According to WHO stroke is defined as "acute outset of neurological dysfunction due to abnormality in cerebral circulation with consequent signs and symptoms that corresponds to involvement of focal area of brain lasting more than 24 hours" [2]. According to W.H.O (16 November 2011) the incidence of stroke in India was 130/100,000 individuals every year [3]. Now in 2022 it is 203/100,000 [4]. The Indian Council of Medical Research estimates that among the non-communicable disease, stroke contributes for 41% of deaths and 72% of disability [5], [6].

Recovery from acute stroke impairment is generally unaccomplished and post-stroke patients are also at a high risk for falls and impaired functional independence due to decreased concentration, gait velocity, sensation, mobility, and balance. The stroke patients are easily to fall down due to balance dysfunction which affected the daily life activities such as walking, sitting without support [7], [8]. Pusher syndrome is also a cause of balance impairment in stroke patients [9]. The falls lead to impairment in social interaction, less self-confidence and lack of the daily activity and contributing decreases in functional activity and dependence [10]. In additions, 60% of stroke patients have disabilities in the arm or leg and one-third need to stay in the nursing home or tools dependency for the independent life [11].

Balance is the condition in which all the forces acting on the body are balanced in such a way that the centre of mass is within the boundaries of the base of support, Stroke patients suffer from balance disability due to the result of the abnormalities in the proprioceptive system [12]. Balance is involved in the integration of the central nervous system for stimuli from auditory, visual, tactile and proprioceptive vessels [13]. Rehabilitation of stroke patients should focus on improving balance ability and mobility for independent movements of the body.

As interventions to improve balance in stroke patients, central nervous system development therapy, and Proprioceptive Neuromuscular Facilitation (PNF) technique have been implemented in clinical practice [14]. Proprioceptive Neuromuscular Facilitation (PNF) technique improves the functions of proprioceptors by stimulating them in the muscles and tendons. It also increases muscle strength, flexibility, mobility and balance [15]. Proprioceptive Neuromuscular Facilitation (PNF) technique also help to increase muscle co-ordination and enhance balance capability. Resistance, reinforcement, manual contact, verbal commands, vision and approximation, stretching, proper timings and pattern are basic procedures for facilitation used in Proprioceptive Neuromuscular Facilitation (PNF) [16]. Proprioceptive Neuromuscular Facilitation (PNF) technique is one of the most wildly used exercise training programs, which is also used with different kinds of exercise patterns to improve the training effects. Looking at previous studies on PNF, it was reported that PNF had a positive effect on balance ability by applying it to stroke patients [17]. Proprioceptive Neuromuscular Facilitation consolidate motor responses and improve neuromuscular control and maximize muscles response. Therefore, this standardized review seeks to evaluate the efficacy of Proprioceptive Neuromuscular Facilitation (PNF) techniques in improving balance and mobility in stroke survivors to provide evidence for clinical practice.

A stroke is a medical condition in which poor blood flow to the brain causes cell death [18]. Stroke is also called as Brain Attack [19]. Symptoms of stroke include trouble walking, speaking and understanding, as well as paralysis or numbness of the face, arm or leg [20]. The risk factors for stroke are same to coronary heart disease and other vascular diseases. Effective prevention strategies include targeting the key modifiable factors of stroke hypertension, elevated lipids and diabetes. Risks due to lifestyle factors can also be addressed smoking, low physical activity levels, unhealthy diet and abdominal obesity [21].

Balance and Mobility

Balance is decreased in people with hemiplegia and hemiparesis. A person with hemiplegic, posture, modulation and co-ordination of reciprocal movements, which are required for normal balance and mobility, are usually impaired [22], [23]. After a stroke, moving from one place to another and keeping your balance require further attention, and it's difficult. Dealing with any condition that needs more concentration could affect your balance and mobility. A person with ataxia has difficulty in controlling smooth movements and balance. Movements of your upper and lower limbs, and the body tend to be dizzy, arms or legs can pass over the target. It is difficult to maintain balance while sitting and standing. If a stroke happens in your cerebellum or brainstem, the areas that controls balance in the brain, you may be left with vertigo. This means having a feeling that you or the world around you is moving or spinning, you can feel unsteady or lose your balance [24], [25], [26]. Restoration of ambulation ability and improvement in mobility, are important physical therapy goals for patients with stroke.

Stroke-related motor impairments restrict mobility including reduced balance, independence, and participation in life-role or day today activities [27], [28]. An important factor that helps explain mobility restrictions after stroke is the perceived challenge of walking, as measured by self-reported higher levels of state anxiety [29]. Rehabilitation improves balance and mobility by using proprioceptive neuromuscular facilitation (PNF) technique. Many drugs are available for post stroke recovery like Levodopa, Carbidopa, Carisoprodol, Ozobax etc., it acts by increasing dopamine in the brain and acting on Gamma aminobutyricacid (GABA) which work on central nervous system. But these drugs are not as much as effective alone without proprioceptive neuromuscular facilitation [27].

Proprioceptive Neuromuscular Facilitation (PNF) stands as a versatile and effective therapeutic approach widely used in rehabilitation and physical therapy. Originally developed in the mid-20th century by physical therapists Herman Kabat, Margaret Knott, and Dorothy Voss, PNF has evolved into a cornerstone of modern rehabilitation practices. This technique integrates principles of neurophysiology and functional anatomy to enhance flexibility, strength, and coordination, making it a valuable tool in the rehabilitation of various musculoskeletal conditions. To comprehend the essence of PNF, it is essential to delve into its underlying mechanisms, the intricacies of its execution, and its profound clinical significance. Proprioceptive Neuromuscular Facilitation (PNF) is a stretching technique utilized to improve muscle elasticity and has been shown to have a positive effect on active and passive range of motions [30], [31], [32]. Research behind stretching has been relatively inconclusive in examining the effects of static stretching, and PNF stretching on outcome measures, such as injury prevention and athletic performance [33]. Proprioceptive neuromuscular facilitation (PNF) integration pattern stimulates the proprioceptors with in the muscle and tendon to enhance the performance, flexibility and balance. It is generally effective in maintaining the reaction of exercise unit by increasing the co-ordination which react to the stimulation in muscular strength and flexibility [34].

The Mechanism of Proprioceptive Neuromuscular Facilitation: A Neurophysiological Ballet

At its core, PNF operates on the principle of exploiting the body's proprioceptive feedback loops and neuromuscular responses. Proprioception, the body's ability to sense its position in space, and neuromuscular control, the coordination between nerves and muscles, are intricately connected. PNF takes advantage of this connection, using specific movement patterns and techniques to stimulate and enhance neuromuscular communication [31].

Neuromuscular Stimulation, Neuroplasticity and Motor Learning

Simultaneously, PNF employs specific patterns of movement to stimulate the neuromuscular system. This involves activating muscle groups in a coordinated manner, eliciting a series of muscle contractions and relaxations. The carefully designed sequences of PNF exercises target not only the primary muscle involved but also its synergists and antagonists, fostering a more comprehensive neuromuscular response [30]. Beyond immediate neuromuscular responses, PNF leverages neuroplasticity – the brain's ability to reorganize itself in response to new stimuli and experiences. Repetition of PNF exercises fosters motor learning, facilitating the creation of new neural pathways and reinforcing more efficient movement patterns. This neuroplastic adaptation is particularly valuable in rehabilitation scenarios, aiding in the recovery of motor function following injury or neurological impairment [32].

Execution of Proprioceptive Neuromuscular Facilitation: A Dance of Patterns and Techniques

The execution of PNF involves a systematic and dynamic interplay between the therapist and the patient. While there are various PNF patterns and techniques, some fundamental principles guide the implementation of this approach. The most commonly used PNF patterns include the Diagonal Patterns (D1 and D2), which simulate the natural diagonal movements of the body [33].

1. Diagonal Patterns (D1 and D2)

A. D1 Flexion Pattern

Upper Extremity: Involves flexion, adduction, and external rotation.
Lower Extremity: Involves flexion, abduction, and external rotation.

B. D2 Extension Pattern

Upper Extremity: Involves extension, abduction, and internal rotation.
Lower Extremity: Involves extension, adduction, and internal rotation.

Clinical Significance of Proprioceptive Neuromuscular Facilitation

Orthopaedic Rehabilitation

Muscle Imbalances: PNF is particularly effective in addressing muscle imbalances by promoting coordinated activation of agonist and antagonist muscle groups. Range of Motion (ROM): The stretching techniques inherent in PNF contribute to improved joint flexibility and increased range of motion, essential in the rehabilitation of orthopaedic conditions [35].

Neurological Rehabilitation

Stroke Rehabilitation: PNF plays a pivotal role in stroke rehabilitation by promoting neuroplasticity and restoring functional movement patterns. Spinal Cord Injuries: Individuals with spinal cord injuries benefit from PNF's emphasis on enhancing neuromuscular control, contributing to improved mobility [35].

Geriatric Rehabilitation

Fall Prevention: PNF exercises can be tailored to address balance deficits in the elderly, reducing the risk of falls. Functional Independence: PNF's focus on enhancing functional movement patterns is particularly beneficial for older individuals striving to maintain independence in daily activities [35].

Paediatric Rehabilitation

Developmental Disorders: PNF principles are adapted for paediatric populations to address developmental disorders and improve gross and fine motor skills. Cerebral Palsy: PNF is employed to enhance motor function and coordination in children with cerebral palsy, contributing to improved mobility [35].

2. RELATED WORK

1. **Poonam Chaturvedi, PNF in acute stroke, MOJ Anatomy & Physiology Volume 5 Issue 6 – 2018, November 27, 2018, page no.391–399.**

- There are several different approaches for treatment after stroke. These can considerably be divided into approaches that are grounded on neurophysiological, motor learning, or orthopaedic approaches. Neurophysiological principles are based on the science of understanding the physiology that helps Central Nervous System function and these approaches utilize repeatedly. It contributes to the confirmation and reorganization of the Central Nervous System functions.

2. **Phan The Nguyen, Proprioceptive Neuromuscular Facilitation-Based Physical Therapy on the Improvement of Balance and Gait in Patients with Chronic Stroke, Life 2022, June 2022, page no.882**

- The present study aims to determine the potential benefits of PNF on balance and gait function in patients with chronic stroke a organized database search was conducted for randomized control trials (RCTs) that finds the effects of PNF intervention in patients with chronic stroke using balance and gait parameters as after effects are measured.

3. **Yan-Fei Li, Effectiveness of proprioceptive neuromuscular facilitation techniques in improving balance in post stroke patients, Brain Network and Modulation, Published by Wolters Kluwer-Medknow March 2022, Volume 1, Issue 1.**

- Stroke patients require rehabilitation programs to improve their functioning and quality of life. Proprioceptive neuromuscular facilitation is a widely used recovery technique in clinical establishments. This study aimed to estimates the effectiveness of proprioceptive neuromuscular facilitation technique in enhancing balance and mobility in post stroke patients through clinical investigations.

4. **Krishna Shinde, Effectiveness of Trunk PNF after stroke, National Journal of Medical and Allied Sciences, Vol 3 issue 2. 2014, page no. 29-34.**

- Stroke is a common neurological condition, defining a major reason of disability. It is considered as a significant health case, which needs a continuous and wide-ranging healing. This investigation shows that stroke survivors may get help from trunk PNF approach for healing during acute and sub-acute stages to make better the trunk control and balance in stroke patient.

3. METHODOLOGY

"A literature review is a systematic, precise, and predictable design for recognizing, reviewing and analyzing the existing body of recorded documents". The goal of document analysis is to provide access to information that does not need to be produced based on the researcher's data collection. The two main goals of literature reviews are usually as follows: first, they provide an overview of the body of research by highlighting trends, topics, and problems [36].

Based on Ballad and Montgomery's guidelines, an overview of articles was done in order to compare and contrast literature review publications [37]. This type of review involves methodically searching for, choosing, analyzing, and synthesizing research findings in accordance with predetermined principles. An overview of the literature that aims to survey it and explain its characteristics is provided in this study using a literature analysis [38], [39].

Several works served as inspiration for data searching and selection procedures, the search was conducted in three relevant databases (Scopus, ISI Web of Science, Google Scholar, and Science Direct,). Only reviews written in English and published in peer-reviewed journals were chosen. The articles were first chosen by removing duplicates, and then the title, keywords, and abstract were read. The publications' alignment with the paper's subject was then confirmed, and the remaining material was then read through to the end. The publications that passed the third selection criteria were those whose literature reviews were utilized for the main body of the work and whose search terms had something to do with the topic of the paper. Alternatively, if the goals of the literature review paper were relevant to the paper but were not made clear in the text, those publications were also chosen. To make sure that significant publications were not omitted, the retrospective technique was used [40]. As seen elsewhere, this process involves looking up the references that the study cites. The references of the chosen papers were examined. Initially, it was confirmed if the publication was a literature review; next, the title, keywords, and abstracts were examined; finally, a full reading was carried out, leading to the inclusion of other publications. The retrospective method ensured the inclusion of studies not indexed in the three databases consulted and was especially

significant because the term "literature review" was not originally used in the first literature reviews published in papers [41].

After the initial reading that presents the inclusions and exclusions, a second reading was conducted in which each publication's primary concepts were emphasized. A third reading was subsequently completed in order to do a content analysis and categorize the publications' material based on the predetermined standards. Some points were rearranged or grouped during the content analysis, necessitating further reads. The benefits and barriers found in the paper were categorized as external (related to customers and context) and internal (related to design, economy, and operations). Environmental and social barriers and rewards connected to context were also separated out [39]. In order to identify, analyze, and evaluate previous published papers on the topic, an efficient and precise procedure was followed during the literature evaluation for this study. Providing thorough insights without depending exclusively on the researcher's data collection was the aim of document analysis. The review's main objective was to provide an overview of the corpus of research by emphasizing issues, trends, and subjects.

4. RESULTS AND DISCUSSION

The extensive and systematic literature review process used in this study article increases the credibility of the findings and serves as a solid platform for the future discussions and conclusions. The incorporation of varied sources, the use of retrospective approaches, and the organized classification of content all contribute to the richness and complexity of the literature review. The systematic literature review and document analysis resulted in a compelling body of evidence supporting the efficacy of Proprioceptive Neuromuscular Facilitation (PNF) techniques in improving mobility, balance, and strength in chronic stroke patients. The thorough strategy used to collect and analyze relevant material provides a solid foundation for understanding PNF's therapeutic advantages in the setting of chronic stroke rehabilitation.

The aggregated results of research studies, clinical trials, evidence-based studies, and case reports consistently confirm the effectiveness of Proprioceptive Neuromuscular Facilitation techniques in addressing various physical challenges faced by chronic stroke patients, providing valuable insights for medical professionals and researchers in the field of rehabilitation these are some outcomes mentioned below.

1. Comparative Study on Gait Training and Balance (RVS College of Physiotherapy) [42].
   PNF was compared with the Bobath approach in a study focusing on gait training and balance among chronic stroke patients. Results indicate that PNF significantly improves mobility, corrects postural alignments, and enhances balance, contributing to stable mobility. Noteworthy improvements were observed in static and dynamic balance, weight support on the more affected side, and dynamic balance ability for the transfer of the centre of gravity.
2. Ramp Gait Training (Korea Nazarene University, Republic of Korea) [43].
   Hemiplegic patients undergoing ramp gait training with PNF techniques experienced a significant improvement in balance ability. The study underscores the effectiveness of PNF in facilitating balance recovery during rehabilitation training.
3. Improvement in Balance (General Research Article) [44].
   A research article reports a 20% improvement in balance within the training group following the application of PNF techniques.
4. Effectiveness in Improving Static and Dynamic Balance (Routine Physical Therapy Comparison) [45].
   PNF is deemed effective in improving static and dynamic balance in post-stroke patients, surpassing routine physical therapy.
5. Improvements in Balance, Strength, and Mobility (University of the Philippines Manila) [46].
   PNF is shown to enhance balance, strength, and mobility in older adults with chronic stroke, aligning with literature on improved functional mobility, gait, and balance.
6. Experimental Research on Gait Velocity and Mobility (Preliminary Data) [47].

Preliminary results from experimental research suggest that PNF techniques improve gait velocity, mobility, and balance in individuals with chronic stroke.

7. Evidence-Based Study (Last 10 Years) [48].
   A comprehensive evidence-based study spanning a decade and including 127 articles concludes that PNF techniques are consistently more effective in treating chronic stroke patients.
8. Randomized Controlled Trial on Cardiorespiratory Training (Various Diseases) [49].
   A randomized controlled trial affirms the efficacy of adding PNF to cardiorespiratory training in post-stroke patients, supporting PNF as an effective treatment.
9. Trunk PNF Patterns for Trunk Control (Trunk Impairment Scale) [50].
   Analysis reveals that trunk PNF patterns are effective in improving trunk control, static and dynamic sitting balance, and coordination in stroke patients, as assessed by the Trunk Impairment Scale.

5. CONCLUSION

In the intricate landscape of stroke consequences, individuals and their caregivers face a heterogeneous journey encompassing immediate challenges, long-term implications, and emotional upheavals. Stroke's abrupt disruption of the brain's blood supply initiates a cascade of neurological impairments, leaving survivors grappling with physical, emotional, and cognitive repercussions. The toll on independence, mobility, and communication can be overwhelming, necessitating not only individual resilience but also robust support systems. The emotional aftermath of stroke is profound, extending beyond the individual survivor to impact their entire support network. Coping with loss, adapting to newfound realities, and navigating the unpredictable nature of stroke demand resilience and understanding. Recognizing the emotional toll is a crucial step toward holistic stroke care, emphasizing the need for comprehensive support mechanisms and professional guidance.

Long-term cognitive implications further complicate the journey, affecting memory, attention, and executive functions. The challenges in communication, exemplified by conditions like aphasia and apraxia, underscore the need for specialized therapeutic interventions. This intricate web of physical and cognitive challenges necessitates a continuum of care, weaving together medical expertise, technological innovations, and a patient-centred approach. As stroke survivors embark on the road to recovery, physical limitations become apparent, requiring dedicated rehabilitation efforts. Proprioceptive Neuromuscular Facilitation (PNF) emerges as a dynamic and versatile therapeutic powerhouse, offering a structured approach to neuromuscular re-education. From addressing muscle imbalances to enhancing functional movement patterns, PNF finds application across a spectrum of conditions, including orthopaedic, neurological, and geriatric rehabilitation.

In conclusion, strokes and their aftermath demand a comprehensive understanding of the physical, emotional, and cognitive dimensions. The journey of recovery is a collaborative effort, involving healthcare professionals, caregivers, and survivors themselves. PNF, with its rich history and ongoing innovations, stands as a beacon in the rehabilitation landscape, offering promise for improved functional outcomes and enhanced quality of life. The continuous interplay between medical advancements, technological innovations, and the human spirit embodies the enduring pursuit of excellence in stroke care and rehabilitation. As we navigate the complex realities of stroke, the resilience of individuals, the dedication of caregivers, and the evolution of therapeutic modalities like PNF collectively shape a future where stroke survivors not only overcome challenges but thrive in their pursuit of a fulfilling life.

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Authors Contributions Statement

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Shreyash A. Manapure	✓	✓	✓		✓	✓		✓	✓	✓	✓		✓	✓

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

Conflict of Interest Statement

The authors declare that there are no conflicts of interest regarding the publication of this paper.

Informed Consent

All participants were informed about the purpose of the study, and their voluntary consent was obtained prior to data collection.

Ethical Approval

The study was conducted in compliance with the ethical principles outlined in the Declaration of Helsinki and approved by the relevant institutional authorities.

Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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BIOGRAPHIE OF AUTHOR



Shreyash A. Manapure, is affiliated with the Department of Pharmacology and is actively involved in interdisciplinary health and rehabilitation research. His academic interests focus on neurological rehabilitation, stroke recovery strategies, physiotherapeutic interventions, and evidence-based healthcare practices. He has contributed to scholarly work exploring proprioceptive neuromuscular facilitation techniques and their clinical applications in improving balance and mobility among stroke survivors. His research emphasizes improving patient outcomes, functional independence, and quality of life through integrated therapeutic approaches and scientific literature analysis. Email: shreyashmanapure6@gmail.com