Original Article

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Effect of Pelvic Proprioceptive Neuromuscular Facilitation on Balance, Postural Sway and Quality of Life in Chronic Stroke Patients: A Case Series

Physiotherapy Section

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ABSTRACT

Introduction: Among long-term stroke survivors who are also chronic stroke patients, balance impairments are common, leading to increased postural sway and reduced Quality of Life (QOL). Pelvic Proprioceptive Neuromuscular Facilitation (PNF) is a targeted treatment approach focused on the pelvic region to improve coordination, mobility, and stability, thereby enhancing daily functioning and well-being.

Aim: To determine the effect of pelvic PNF on balance, postural sway, and QOL in chronic stroke patients.

Materials and Methods: The present case series included five patients (4 males and 1 female) aged 40-65 years with chronic stroke. Baseline data for balance, postural sway, and QOL were collected pre and post intervention. Balance was assessed with the Berg Balance Scale (BBS); postural sway was measured with a sway meter; QOL was evaluated with the Stroke-Specific Quality of Life (SS-QoL) scale. The effectiveness of pelvic PNF was determined by comparing pre and post intervention data.

Results: A paired t-test showed significant differences between pre and post intervention scores ($p<0.05$). The BBS score increased from a preintervention mean of 30.8 to a post intervention mean of 38.2, indicating improved balance. Postural sway decreased in all directions: anterior sway from 6.9 cm preintervention to 5.3 cm post intervention, and posterior sway from 8.6 cm to 7.2 cm. Similarly, right lateral sway improved from 8.1 cm to 6.9 cm, and left lateral sway decreased from 7.1 cm to 5.9 cm, reflecting better stability. The SS-QoL score rose from 92.4 preintervention to 109.2 post intervention, indicating improved quality of life.

Conclusion: Pelvic PNF improves balance, reduces postural sway, and enhances quality of life in chronic stroke patients.

Keywords: Chronic illness, Functional independence, Motor skills disorders, Movement disorders, Pelvic girdle, Stroke rehabilitation

INTRODUCTION

Stroke is a common neurological disorder and a significant cause of disability [1]. The Global Burden of Disease (GBD) Injuries and Risk Factors Study reports that between 1990 and 2019 the number of global Cardiovascular Disease (CVD) cases, including stroke, nearly doubled from 271 million to 523 million [2]. In India, strokes occur at a rate of 124 per 100,000 individuals per year, with urban areas showing a prevalence of 136 per 100,000 and rural areas at 165 per 100,000 [3,4].

The term "stroke" was coined in 1689 by William Cole in his work 'A Physico-Medical Essay Concerning the Late Frequencies of Apoplexies' [5,6]. Stroke is also called a "cerebrovascular accident," a "brain attack," or "apoplexy" [1,7]. According to the World Health Organisation (WHO), stroke is the sudden onset of focal neurological deficits persisting for 24 hours or leading to death, due to vascular causes [5,8-10]. Stroke primarily results in physical disability in adults. However, it remains a major cause of death in many countries [11,12]. Stroke is classified as ischaemic or haemorrhagic. Ischaemic strokes result from obstruction, whereas haemorrhagic strokes involve rupture of a blood vessel. The latter can lead to increased intracranial pressure, causing brain tissue damage and reduced blood flow to certain areas [4,10]. Approximately 80-85% of strokes are ischaemic, with the remaining 15-20% being haemorrhagic [11]. Hypertension, diabetes mellitus, cardiac issues (such as atrial fibrillation), smoking, hyperlipidemia, alcohol use, substance misuse, obesity, sedentary behaviour, and inflammation are among the controllable risk factors for stroke. Non-modifiable risk factors include age (risk doubles after 55), genetic predisposition, and sex, with premenopausal women at higher risk [13].

Following a stroke, common symptoms include motor impairments such as difficulty with walking and balance, decreased sensation on the contralateral side of the body, abnormal movement patterns, atypical reflexes, coordination difficulties, sensory distortions, cognitive limitations, visual impairments, depressive symptoms, and difficulties with maintaining posture and balance [14]. In stroke patients, pusher syndrome can also result in impaired balance [15].

Because of their impaired balance, stroke patients are prone to falls, which can affect daily activities such as walking. These falls can impair social interactions, lower self-esteem, and reduce participation in daily activities, contributing to a decline in functional activity and independence. The symptoms of balance dysfunction include a hemiplegic gait pattern, postural and sway instability, decreased walking speed, and reduced weight shifting on the affected leg. Also, one-third of stroke patients require nursing-home care or rely on assistive devices to live independently, and 60% of them suffer from arm or leg impairments [12].

Physical therapy rehabilitation significantly contributes to the development of independence. The fundamental facilitation techniques used in PNF include irradiation, resistance, reinforcement, manual contact, appropriate body mechanics and postures, verbal commands, traction, visual input, approximation, stretching, appropriate timing, and patterning [15].

PNF focuses on the interaction of sensory systems that provide data about the position and motion of the body. Neuromuscular refers to the interaction between nerves and muscles, while proprioceptive describes this sensory data. Enhancing coordinated movements is the essence of facilitation. PNF combines diagonal movement patterns with techniques to increase muscle strength, endurance, and motor skills in physical therapy. It was introduced by Kabat, Knott, and Voss in the 1940s and 1950s [16].

The pelvis is an important element of overall posture. It supports the body while sitting and facilitates weight transfer from the spine to the lower limbs. Control of pelvic motion is important for maintaining whole-body balance in different planes. Pelvic movements in the lateral and anteroposterior directions are important for weight bearing and transfers. Pelvic movements are integrated into all functional activities, including post-stroke rehabilitation [17]. Pelvic PNF enhances pelvic control, which is crucial for trunk stability, balance, and proprioceptive stimulation. Pelvic PNF techniques facilitate neuromuscular mechanisms through the application of stretch, specific movement patterns, and maximal resistance to induce irradiation [18]. This multi-planar manual technique, applied by physical therapists, helps patients improve their functional status. This approach can improve pain management, Range of Motion (ROM), muscle strength, endurance, and coordination. It has been widely used in early rehabilitation for neuromuscular re-education to improve motor function in patients with stroke. It trains muscle contractions to increase strength, flexibility, balance, and coordination, and encourages the exploration of postural reflexes and the restoration of proprioceptive receptors in muscles and tendons to enhance muscular function [19]. Preliminary case reports reveal that a PNF-based program has the potential to improve motor function in older adults with chronic stroke [19]. Studies suggest that Pelvic PNF is as effective as traditional therapy for post-stroke balance improvement and often yields faster results [20].

Hence, this case series aims to investigate the effect of Pelvic PNF on balance, postural sway, and Quality of Life (QOL) in chronic stroke patients.

MATERIALS AND METHODS

The present case series included five patients (4 males and 1 female) with chronic stroke or their legal representatives provided written informed consent after receiving complete information on the study's purpose, risks, benefits, procedures, and confidentiality. The cases were recorded from November 2024 to January 2025. In this case series, both the therapist and the patients were aware of the intervention and procedures. Participants were selected by convenience sampling according to the inclusion and exclusion criteria.

Inclusion criteria: Individuals aged 40 to 65 years, included both males and females. Subjects who can sit independently; subjects with Brunnstrom stages 4-5 [21]; subjects who can follow commands effectively; subjects who can stand for 20 seconds unsupported under observation.

Exclusion criteria: A history of cognitive impairment in the past year; cardiovascular and/or cardiopulmonary disorders in the past year; respiratory disorders in the past year; deformities or contractures of the spine or lower limbs; patients who have undergone any spine or lower-limb surgery in the past year; other neurological abnormalities in the past year; patients currently enrolled in another trial.

The baseline demographic data of all cases has been represented in [Table/Fig-1].

Case no.	Age	Gender	Chronicity of stroke
1	47	Male	3.5 years
2	52	Male	2 years
3	42	Male	17 months
4	57	Male	3 years
5	49	Female	9 months

[Table/Fig-1]: Patient's demographic data.

Case 1

A 47-year-old male presented with profound weakness and restricted mobility on the right side. They report difficulty walking independently, impaired balance, and frequent near-falls. Postural control was compromised, increasing fall risk. The patient also complained of chronic fatigue and pain in the right shoulder due to muscular strain.

Case 2

A 52-year-old male post-stroke patient experienced significant muscle stiffness and spasticity in the left limbs. They report discomfort, joint tightness, and limited ROM. Functional tasks such as dressing and grasping were extremely difficult due to loss of fine motor control and persistent discomfort in the upper extremity.

Case 3

A 42-year-old male presented with slurred, effortful speech and difficulty swallowing solids and liquids. These symptoms developed following a cerebrovascular incident. Speech was slow and unclear, affecting communication; swallowing issues have led to reduced oral intake and increased caregiver dependence.

Case 4

A 57-year-old male reported numbness and tingling on the left side of the body, particularly in the hand and foot. These sensory deficits impair coordination, resulting in clumsy movements, frequent object dropping, and difficulty navigating stairs or uneven surfaces safely.

Case 5

A 49-year-old female reported increasing forgetfulness, difficulty concentrating, and sudden mood swings post-stroke. Emotional lability and low confidence interfere with their ability to perform activities of daily living independently. Additionally, they experience urinary urgency, further compromising their quality of life.

Timeline: Pelvic PNF techniques, including rhythmic initiation, slow reversal, and stabilising reversal, were performed five days a week for 30 minutes each session over four weeks. The intervention targeted anterior pelvic elevation and posterior pelvic depression and aimed to improve postural control and stability. Adequate rest time was provided for each participant according to their comfort level.

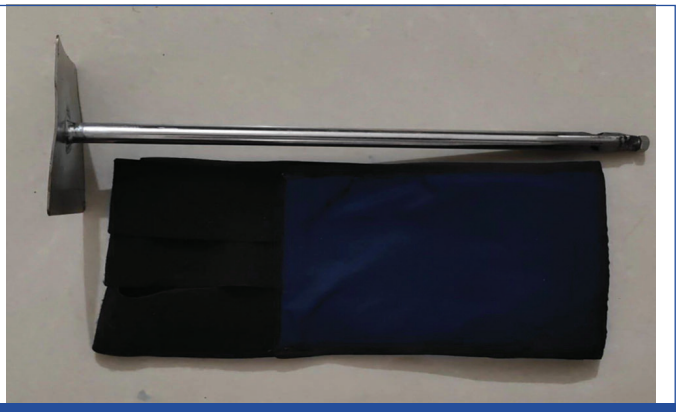
Study Procedure

A thorough diagnostic evaluation of the patients and a review of medical history, with emphasis on comorbidities and stroke chronicity, were conducted before the start of the intervention. Only patients with Brunnstrom stages 4-5 [16,21,22] were included. The assessment of balance, postural sway, and QOL was conducted using validated tools to ensure accurate measurement of functional improvements in stroke patients.

Balance was assessed using the Berg Balance Scale (BBS) [23], a 14-item test evaluating sitting, standing, and dynamic balance, with a total score ranging from 0 to 56. Higher scores indicate better stability and a lower risk of falls. The BBS is a highly reliable and valid tool for assessing balance and fall risk, particularly in stroke survivors and older adults. Studies have demonstrated excellent internal consistency (Cronbach's alpha 0.92-0.98), interrater reliability (intraclass correlation coefficients, ICCs, 0.95-0.98), intrarater reliability (ICC 0.97), and test-retest reliability (ICC 0.98) [24].

Postural sway was assessed using the Lord Sway Meter [25], which measured Anteroposterior (AP) and Mediolateral (ML) sway displacements at the Posterior Superior Iliac Spine (PSIS) level,

capturing involuntary postural adjustments. A self-made instrument consisting of a firm belt with a 40 cm rod attached to it was used. The belt was tied at the level of the PSIS, and the 40 cm rod carried a pen pointer. Postural sway was measured in anterior, posterior, right lateral, and left lateral directions. To exclude visual influence, the sway meter was positioned at the level of the anterior superior iliac spine. Participants stood on a sheet of paper with foot imprints about three inches apart, with a graph sheet placed behind the subject to keep the rod horizontal. The procedure was repeated for three trials with eyes open, with a 5-10 second rest between trials. The maximum deviation across the three trials was used for analysis. Post-procedure comments were collected from participants to assess feasibility and limitations of using the sway meter. The sway meter is a reliable tool for assessing postural sway and has demonstrated reliability across trials, with ICCs ranging from 0.654 to 0.944 [Table/Fig-2] [26].



[Table/Fig-2]: Sway meter (40 cm long rod and firm soft belt).

The QOL assessment was performed using the SS-QOL Scale (Stroke-Specific Quality of Life), a 49-item self-report questionnaire covering 12 domains, including mobility, self-care, mood, social participation, and energy levels. Patients rated their experiences over the past week on a 5-point Likert scale, with higher scores indicating greater functional independence and overall well-being. The SS-QOL Scale is a reliable and valid measure for assessing QOL in stroke survivors, with Cronbach's alpha values between 0.73 and 0.89, indicating strong internal consistency. It also has high test-retest and inter-rater reliability, confirming its stability. Construct validity is demonstrated by significant correlations with established measures such as the SF-36 (mobility, r^2=0.41, p<0.001) and the Beck Depression Inventory (BDI) (r^2=0.43, p<0.001).

This holistic assessment approach allowed a detailed understanding of the impact of pelvic PNF therapy on balance, postural stability, and the daily lives of stroke survivors. The results of these assessments provided a baseline for comparison with post intervention data [Table/Fig-3].

Variables	Details
Duration	5 days a week for 4 weeks.
Technique	Rhythmic initiation and slow reversal, stabilising reversal
Sessions	Each technique was performed for 10 minutes with adequate rest time based on participant comfort.
Positioning	• Treatment performed on the affected side • Hips extended to 100 degree and knee flexed to 45 degree • Pillow placed under the neck for support.
Therapist positioning	• Positioned behind the patients, facing towards the sacrum. • Hands placed on the ischial tuberosity for posterior depression. • Hands placed on iliac spine for anterior depression.
Week 1-2: Rhythmic Initiation	• Facilitated movement patterns and smooth transitions • Started with passive movement, progressed to assisted movement • Verbal cues used to guide pelvic motion • Active-resisted phase introduced gradually with minimal resistance
Resistance and Progression	• Initially, no resistance in the passive and assisted phase • Minimal resistance applied in the active movement phase • Progressed based on smooth execution with minimal compensations
Week 2: Slow Reversal	• Alternated strong agonist contractions with weaker antagonist contractions • Performed in a rhythmic, controlled pattern
Resistance and Progression	• Resistance increased progressively as tolerated • Progressed when the patient could perform 10 repetitions with proper control and minimal effort
Week 3-4: Stabilising reversal	• Used isotonic contractions with graded resistance to enhance postural stability • Prevented large displacements while activating stabilising muscles
Resistance and progression	• Resistance applied based on the patient's ability to maintain stability • Progressed when the patient could sustain postural control against resistance for 15-20 seconds without compensation
Guidelines followed	CARE guidelines for case series

[Table/Fig-3]: Pelvic Proprioceptive Neuromuscular Facilitation (PNF) intervention [17].

STATISTICAL ANALYSIS

The Statistical Package for the Social Sciences (SPSS) software, version 21, was used to examine the data. A paired t-test was conducted on pre and post intervention scores for balance, postural sway, and QOL. Statistical significance was set at p<0.05. A 95% confidence interval was used.

RESULTS

The data indicate significant improvements in balance, postural stability, and QOL following the intervention. The BBS scores increased from 30.8±7.2 preintervention to 38.2±6.4 post intervention, indicating enhanced balance [Table/Fig-4,5]. Postural sway decreased in all directions, reflecting improved postural control. For example, anterior sway decreased from 6.9±1.3 cm to 5.3±1.1 cm, and posterior sway decreased from 8.6±1.1 cm to 7.2±0.9 cm. Right lateral sway declined from 8.1±1.4 cm to 6.9±1.2 cm, and left lateral sway declined from 7.1±1.2 cm to 5.9±1.0 cm. These changes indicate improved stability and a lower risk of falls. Additionally, SS-QoL scores increased from 92.4±9.3 preintervention to 109.2±11.5 post intervention, signifying a substantial enhancement in perceived QOL among participants [Table/Fig-4,5].

Outcome measures	Case 1	Case 2	Case 3	Case 4	Case 5
Berg Balance Scale (BBS)	27	34	25	40	28
Postural sway: Anterior (cm)	8	5	7	5	7.5
Posterior (cm)	7	8	9	7	9
Right lateral (cm)	7	6	9	6	10
Left lateral (cm)	6	8.5	7	6.5	7
SSQOL-score	87	101	85	110	92

[Table/Fig-4]: Score of pre-assessment of outcome measures before four weeks. cm: centimetres, SSQOL: Stroke-specific quality of life

Across all parameters, the improvements were statistically significant (p<0.05). Specifically, BBS improved from 30.8±7.2 to 38.2±6.4 (t=-8.64, p<0.001); posterior sway reduced from 8.6±1.1 cm to 7.2±0.9 cm (t=7.67, p=0.00003); SS-QoL increased from 92.4±9.3 to 109.2±11.5 (t=-4.87, p=0.00088) [Table/Fig-6].

DISCUSSION

The patients in this case series presented with common post-stroke symptoms, including reduced functional mobility, balance problems, and gait difficulties. Earlier research indicates that stroke survivors frequently have motor deficits such as postural instability and balance dysfunction, which is consistent with findings by Pachruddin I. et al., (2020) and Shah S et al., (2022) [12,14]. Significant improvements in balance following pelvic PNF intervention were demonstrated by the BBS assessment, which was used in this case series to evaluate these difficulties. The literature documents stroke symptoms, particularly hemiplegia, balance problems, and cognitive impairments [10,11]. The symptoms in the case series were not exclusive; rather,

Outcome measures	Case 1	Case 2	Case 3	Case 4	Case 5
Berg Balance Scale (BBS)	34	40	32	48	34
Postural sway: Anterior Sway (cm)	6	4	6	4	6
Posterior (cm)	8	7	7.5	5.5	7.5
Right lateral (cm)	6	5	7.5	5	8
Left lateral (cm)	5	7	6	5	5
SSQOL-score	99	125	95	124	122

[Table/Fig-5]: Score of post-assessment of outcome measure after 4 weeks.
cm: centimetres, SSQOL: Stroke-specific quality of life

Measure	Preintervention mean±SD	Post intervention mean±SD	Paired t-test value	p-value
Berg Balance Scale (BBS)	30.8 ±7.2	38.2±6.4	-8.64	0.00001*
Anterior Sway (cm)	6.9±1.3	5.3±1.1	5.51	0.00037*
Posterior Sway (cm)	8.6±1.1	7.2±0.9	7.67	0.00003*
Right Lateral Sway (cm)	8.1±1.4	6.9±1.2	5.51	0.00037*
Left Lateral Sway (cm)	7.1±1.2	5.9±1.0	4.78	0.001*
SS-QoL Score	92.4±9.3	109.2±11.5	-4.87	0.00088*

[Table/Fig-6]: Pre and post intervention comparison of outcome measures.
Descriptive statistics and Paired t-test, *p-value <0.05, SD: Standard Deviation, cm: centimetres, SSQOL: Stroke-specific quality of life

they align with broader trends observed in stroke survivors. Pelvic PNF is a well-established neuromuscular re-education rehabilitation technique aimed at enhancing motor function, strength, and coordination [19].

As described in this study, PNF therapy includes techniques such as rhythmic initiation, slow reversals, and stabilising reversals, focusing on pelvic control to enhance trunk stability and overall posture. PNF, developed by Kabat, Knott, and Voss in the 1940s-1950s, has been shown to be a useful method for improving motor function in stroke rehabilitation [16]. Pelvic PNF targets the pelvis, which is important for preserving balance during functional tasks [17]. Additional research by Sharma and Kaur (2017) highlighting the significance of pelvic motion in post-stroke recovery is consistent with this focus [18]. Pelvic PNF provides a more targeted intervention than standard rehabilitation techniques, which often employ a broader approach targeting the entire body. Studies suggest that PNF can improve stability and balance as effectively as traditional therapies and may yield faster results [20]. The current study's findings, showing improvements in postural control as measured by both BBS and postural sway assessments, corroborate this conclusion. Earlier research on stroke rehabilitation indicates that early and targeted rehabilitation can lead to significant improvements in strength, balance, and QOL, and the recovery outcomes observed in this case series are consistent with that evidence [20,27]. Pelvic PNF significantly improved stability and decreased postural sway among participants, as measured by the postural sway meter. These findings align with evidence that increasing proprioceptive input through focused methods like PNF can enhance motor coordination and reduce fall risk [18]. The SS-QOL Scale, used in this case series, demonstrated significant increases in quality of life, reflecting greater emotional well-being and functional independence. This is consistent with prior studies showing that stroke patients' overall quality of life improves when their physical function-especially balance and postural stability-improves [27,28]. Regaining functional mobility enables greater participation in daily activities, which can improve psychological outcomes and reduce feelings of dependency [4]. These results provide important new information about pelvic PNF as a rehabilitation technique for stroke patients with persistent deficits. Pelvic PNF offers a focused, efficient method for boosting quality of life, reducing postural sway, and increasing balance in stroke survivors, as demonstrated by comparisons with existing studies. The current findings support pelvic PNF as a viable option to enhance motor function and post-stroke recovery, in line with other research highlighting the potential benefits of PNF in post-stroke rehabilitation.

Patient perspective: All five patients reported notable improvements in mobility, posture control, and balance. They described greater independence in everyday activities, increased stability while walking, and fewer difficulties with weight shifting. Some reported increased endurance, reduced stiffness, and better muscle coordination, which facilitated easier movement. Despite individual differences in response, most participants felt that the therapy improved their overall functioning and quality of life.

Limitation(s)

- There was no control group.
- No long-term follow-up assessment was conducted.
- The intervention period was relatively short.
- The study had a small sample size and did not include objective neurophysiological assessments.
- The inclusion criteria focused on individuals with moderate stroke severity (Brunnström stages IV-V), which means the findings may not apply to patients with severe impairments or those in earlier stages of recovery.
- The study was conducted at a single rehabilitation center; therefore, further research is necessary to examine long-term impacts in a larger patient population and to validate our findings.

CONCLUSION(S)

This case series demonstrates the impactful results of applying pelvic PNF approaches to individuals with chronic stroke. Participants showed notable improvements in balance, motor control, and confidence in Activities of Daily Living (ADLs), as well as a substantial decrease in postural sway, contributing to an overall improvement in QoL. Pelvic PNF offers hope and renewed strength to those recovering from stroke.

Future research should include long-term follow-up, use larger sample sizes, and include objective neurophysiological assessments. Expanding the inclusion criteria to patients with varying stroke severities and conducting multicenter studies would enhance generalisability. Integrating pelvic PNF with other rehabilitation approaches warrants investigation. Lastly, research should explore cost-effectiveness, patient adherence, and satisfaction to support broader clinical implementation.

Ethical Approval: The work has been approved by the appropriate ethical committees related to the institution (Galgotias University Departmental Ethics Committee, on September 09, 2024, with registration number DRC/MPT/13/24). The subject gave informed consent to the work.

Data Declaration: The data used in this case series were collected from patients diagnosed with chronic stroke based on clinical criteria. All data were collected following ethical standards and with informed consent.

Authors' contributions: D, PM, CKS, SG, SZ, and SA conceived and designed the study, performed the research, and collected and organised data. They also analysed and interpreted the data, and wrote the initial and final drafts of the manuscript. D, PM, CKS, SG, SZ, and SA supervised the study and revised and edited all manuscript submission materials. All authors critically reviewed and approved the final manuscript and are responsible for the content and for the manuscript's originality.

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PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: Mar 06, 2025
- Manual Googling: Jul 10, 2025
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- Financial or Other Competing Interests: None
- Was informed consent obtained from the subjects involved in the study? Yes
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