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Effects of gait training with and without proprioceptive neuromuscular facilitation on balance and gait in chronic stroke patients

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Abstract

Introduction. To compare the effects of gait training with and without proprioceptive neuromuscular facilitation (PNF) on balance and gait in chronic stroke individuals.

Methods. It was a double-blind randomized control trial conducted at University Physical Therapy and Rehabilitation clinic, Lahore, Pakistan from March 2020 to November 2020 using non-probability convenient sampling. Sixty patients in the chronic phase of a stroke, aged between 35 and 85 years, were randomly allocated into two groups. Group A received proprioceptive neuromuscular facilitation-based gait training along with routine physical therapy, while group B received only gait training and routine physical therapy. Berg balance scale (BBS) and GAITRite platinum were used as measuring equipment. The rules and regulations set by the ethical committee of the university of Lahore were followed. Data was analysed by a statistical package for social sciences, version 24.

Results. Balance improved more significantly in group A than in group B ($p < 0.05$). Participants improved significantly in terms of stride length ($p < 0.001$), step length ($p < 0.001$), % swing phase ($p < 0.001$), BBS ($p < 0.001$), cadence ($p < 0.001$) and velocity ($p < 0.001$), and decreased significantly for ambulation time ($p < 0.001$), and % stance phase of gait cycle ($p < 0.001$), over the treatment period within both groups. The results of stride length, step length, ambulation time, cadence, velocity, % of swing and stance phase were insignificant for between-group comparisons.

Conclusions. Proprioceptive neuromuscular facilitation-based gait training along with routine physical therapy is more effective in improving balance as compared to routine physical therapy alone. However, for improving gait parameters, proprioceptive neuromuscular facilitation (PNF) proves to be as effective as routine physical therapy and gait training.

Key words: stroke, gait, balance, proprioceptive neuromuscular facilitation, physical therapy

Introduction

Stroke is a medical emergency that occurs when the blood supply to the brain is disturbed and causes a sudden disruption to the neurological system of the body. It may be haemorrhagic or ischemic, depending on the cause [1]. It is ranked as the second common reason of disablement and mortality throughout the globe, while in the United States of America, stroke is ranked third to fourth in number among the causes of increasing death and handicap rates. Mentality, cognition, emotional status, and survival of an individual are badly affected by stroke. Disabilities caused by stroke causes an individual to lose their employability and professional status [2].

According to the International Classification of Functioning, Disability and Health (a classification of health and health-related domains), formulated by the World Health Organization, disability is the result of a relation between the structure or function of the body, limitation in activities and restriction in social participations. Multiple impairments are caused by stroke due to the cessation of the nervous system of the body, which in turn badly affects participation of individuals at the community level [3].

Half body weakness after a stroke is the most challenging impairment [4] and has a negative impact on the balance, walk or gait cycle of a stroke survivor. Eighty percent of the people experience prolonged gait deficits after a stroke. Causes of walking difficulties in a stroke are the uneven tone of body, weakness, obligatory pattern development, impairments in sensory and motor functions, and deficits in the controlling mechanism of the brain. Abnormal swing and stance phase, decreased walking speed, increased ambulation time, and also a decrement in step length and stride length are common presentations [5]. Regaining a normal walking pattern is one of the goals of stroke patient rehabilitation [6].

For promoting independence and reducing disability in the chronic phase of a stroke, physical therapy rehabilitation has an important role. Proprioceptive neuromuscular facilitation (PNF) is one of the effective rehabilitation approaches used nowadays in physical therapy [7].

Neuroplasticity principles and PNF principles are common to each other, as in both of the approaches, the desired movement is repeated again and again, the task is specified, and exercises mimicking the activities of daily living (ADLs) are used, so that the task remains relevant to the patient in order to enhance movement capacity, avoid further deterioration and to enhance the functional independence of individuals [8].

According to the null hypothesis of this study, it is proposed that there is no significant difference in the effects of gait training with and without proprioceptive neuromuscular facilitation on balance and gait parameters in chronic stroke patients. This null hypothesis has to be proved incorrect in order to justify the significance of PNF in the gait training protocol of chronic stroke patients.

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Gunning and Uszynski [9] conducted a systematic review to assess the importance of PNF on walking patterns in the stroke population. The results of 84 trials showed significant improvement in locomotion and gait pattern among stroke patients using PNF principles in rehabilitation.

A randomized control trial conducted by Kumar and Kumar [10] showed the effectiveness of PNF as compared to conventional physical therapy in enhancing gait quality and functional ambulation in post stroke individuals. Zakrzewska and Iłżecka [11] conducted a study to check out the effects of PNF techniques and principles in the rehabilitation of patients with ischemic stroke. They observed the significance of the PNF method in stroke patients, but this research also emphasized the importance of conventional physical therapy for the rehabilitation of post stroke individuals.

In spite of the importance of PNF in rehabilitation plans of care, scientific studies on this topic are still scarce. In most of the published studies, non-weight bearing positions and aquatic environment were used to conduct interventions and also, the interventions did not fulfil the demands of an upright posture, which is important for the gait of an individual. Therefore a study is needed on gait training with and without PNF, which can be carried out in clinical settings, to demonstrate its effectiveness on balance and gait for chronic stroke patients.

Subjects and methods

Participants and study design

Sixty participants (Table 1) for this double blinded randomized controlled trial were recruited from University Physical Therapy and Rehabilitation Clinic (UPTRC) UOL, Lahore, Pakistan, with a 95% confidence interval, statistical power of 90%, having mean Berg balance score of 12.6 and 14.9 and standard deviation of 2.58 and 2.41 in group A and group B respectively [12]. Participants were then randomly allocated into two groups (30 patients per group), group A: experimental group (routine physical therapy and gait training with PNF) and group B: control group (routine physical therapy and gait training alone). The sample size was calculated using open epi software. The trial protocol of this study was approved by an institutional review board of the University of Lahore (IRB-UOL-FAHS/718-IV/2020) and registered in the Iranian Registry of Clinical Trials (IRCT20201101049221N1).

Inclusion and exclusion criteria of study participants

Hemiplegic patients of ages between 35 and 85 years, having a single episode of ischemic or haemorrhagic stroke diagnosed by a neurologist were included in the study. All the patients were in the chronic phase of stroke (duration of stroke for more than six months). Participants were able to understand and follow simple verbal instructions [Mini-Mental Status Examination (MMSE) ≥ 24] [13]. Participants having visual and auditory impairments and with any type of orthopaedic injury that could interfere with walking were excluded from the study. Participants with severe spasticity (modified ashworth scale grade ≥ 3) or severe flaccidity in lower and upper limbs were also excluded.

Measuring equipment

GAITRite platinum [14] was used for evaluation of stride length (cm), step length (cm), ambulation time (s), cadence (steps/min), velocity (cm/s), % of stance phase and % of swing phase of gait cycle before and after interventions. It is a reliable assessment tool [15] which consists of an electronic walkway utilized to measure the temporal and spatial parameters of gait cycle by its pressure activated sensors and is connected to a monitor system where the values of gait parameters can be displayed. In a gait cycle, stride length (cm) is the distance between successive heel contacts of the same foot, while step length (cm) is the distance between heel contact points between both feet [15]. Cadence is the number of steps taken by individual per unit time (steps/min). Velocity is the distance covered per unit time (cm/s). Ambulation time (s) refers to the time duration which the stroke individual took in walking from one side of a mat of GAITRite platinum to the other side (length of GAITRite mat is 5.6 m).

Berg balance scale (BBS) is a valid and reliable scale [16] that was used to evaluate balance of participants before and after interventions. It is a 14-item list with each item consisting of a five-point ordinal scale ranging from 0 to 4. Zero denotes the inability to complete the task, and 4 the maximum ability to accomplish the task. People having a score of 56 are considered to have functional balance. Scores of less than 45 are indicative of increased risk of falls among the elderly [13].

Table 1. Demographic and clinical characteristics of study participants

Characteristics	Group A (PNF along with RPT and GT) *n* = 30 mean ± *SD*	Group B (RPT and GT) *n* = 30 mean ± *SD*
Age (years)	54 ± 9.5	53 ± 9.4
Male, *n* (%)	17 (57%)	15 (50%)
Female, *n* (%)	13 (43%)	15 (50%)
Height (feet)	5.5 ± 0.65	5.4 ± 0.64
Weight (kg)	72.60 ± 12.2	72.37 ± 11.75
Ischemic stroke, *n* (%)	14 (47%)	12 (40%)
Haemorrhagic stroke *n* (%)	16 (53%)	14 (47%)
MMSE	27.53 ± 1.07	27.23 ± 0.89

PNF – proprioceptive neuromuscular facilitation, RPT – routine physical therapy, GT – gait training, MMSE – mini mental status examination score

Procedure

Participants had a detailed examination and screening for assessing their eligibility in the inclusion/exclusion criteria (Figure 1), after giving informed signed consent. Sixty eligible participants were recruited and randomly allocated into group A: experimental group (routine physical therapy and gait training with PNF) and group B: control group (routine physical therapy and gait training alone). After randomization, study participants were only informed about their allocated exercise program, they remained unaware of the interventions in the other group. Participants were assessed at baseline and re-assessed on the outcome scales at the end of treatment i.e. after 6 weeks by the same investigator. The investigator found the participants highly motivated at the end of six weeks. Researchers who assessed outcomes or involved in data analyses were also masked to the group allocation. The treatment was provided at a rehabilitation clinic three days per week on an alternate basis, for six weeks (18 sessions). The screening, detailed neurological examination, pre-post assessments of outcome measures and intervention were performed by different researchers.

Protocol

In group A, routine physical therapy was performed for 20 minutes and PNF with gait training for 30 minutes (total 50 minutes session). Routine physical therapy involved strengthening exercises of the weakened muscles of body, range of motion exercises of whole body and stretching exercises of spastic muscles of the body up to the patient's tolerance [17].

PNF based gait training involved PNF pelvic patterns, PNF lower extremity D1 Flexion and PNF lower extremity D1 extension, each exercise was repeated 10 to 20 times or up to the patient's tolerance, progressed from rhythmic initiation to stabilizing reversals and then followed by dynamic reversals up to the 4th week of treatment session. Other exercises involved pelvic bridging, rolling, sitting and standing exercises and walking practice in parallel bars and treadmill training up to the patients tolerance [8].

Group B had a treatment session of 40 minutes, 20 minutes of routine physical therapy as in group A and 20 minutes of gait training alone, that included pelvic rolling, bridging, sitting and standing exercises and walking practice in parallel bars and treadmill training up to the patients tolerance.

Data analysis procedure

Data was tabulated and analysed by a statistical package for social sciences (SPSS) version 24. Descriptive statistics were generated for all variables. Numerical data like age and time duration were presented in the form of mean ± *SD*. Categorical data like gender and type of stroke were presented in the form of frequency (percentage). After fulfilling the parametric assumptions (by using the Kolmogorov–Smirnov test), Independent *t*-test was used for analysis of stride length, step length, ambulation time and velocity (normality assumption fulfilled) between experimental and control group. For within-group analysis, the paired *t*-test was used.

For the variables that do not fulfil the parametric assumptions (BBS, cadence, % of stance and % of swing phase), the Mann–Whitney *U* test was used for analysis between the experimental and control group while Wilcoxen Signed Rank Test was used for within-group analysis.

$p \leq 0.05$ will be considered significant.

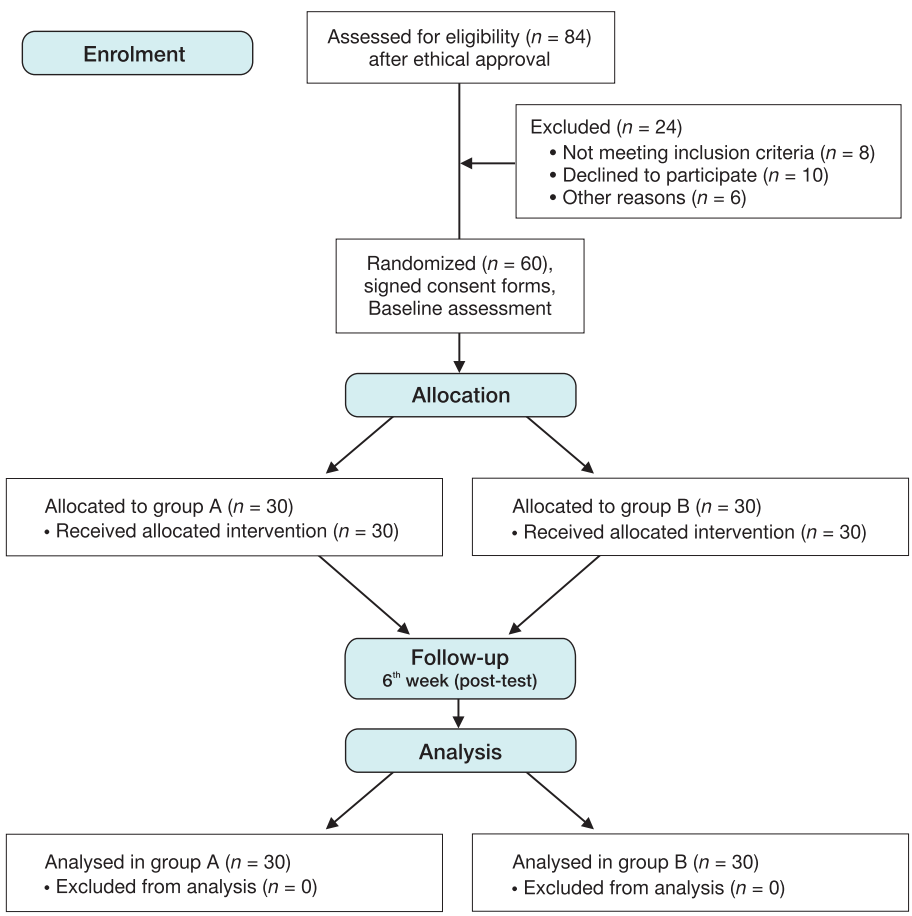

Figure 1. Consort flow diagram showing summary of patient recruitment, randomization and analysis

Ethical approval

The research related to human use has complied with all the relevant national regulations and institutional policies, has followed the tenets of the Declaration of Helsinki, and has been approved by the institutional review board of the University of Lahore (approval No.: IRB-UOL-FAHS/718-IV/2020).

Informed consent

Informed consent has been obtained from all individuals included in this study.

Results

Balance improves more significantly ($p < 0.05$) in group A with PNF as compared to group B without PNF (Table 2). The participants improved significantly for stride length ($p < 0.001$), step length ($p < 0.001$), % swing phase ($p < 0.001$), BBS ($p < 0.001$), cadence ($p < 0.001$) and velocity ($p < 0.001$), and decreased significantly for ambulation time ($p < 0.001$), and % stance phase of gait cycle ($p < 0.001$), over the treatment period within both groups (Table 3 and 4). Results of stride length, step length, ambulation time, cadence, velocity, % of swing and stance phase were insignificant for between-group comparisons (Table 2 and 5).

On the basis of the p value of the mean BBS score ($p < 0.05$), a significant improvement in balance was observed in group A as compared to group B after interventions. On the basis of p values of mean % swing and stance phase and cadence, it was observed that no significant difference was seen in the % swing and stance phase and cadence after treatment between group A and group B.

Table 2. Comparison of balance, % of swing phase, % of stance phase and cadence after interventions between group A and group B (not normally distributed variables). Group statistics

Variables	Group	*N*	Mean	*SD*	*p*-value
BBS pre-test	A	30	32.40	4.54	0.84
	B	30	32.07	4.37	
BBS post-test	A	30	40.57	3.83	0.04
	B	30	38.37	4.03	
SWP pre-test	A	30	25.29	4.95	0.08
	B	30	27.44	4.52	
SWP post test	A	30	32.49	4.62	0.55
	B	30	32.88	4.01	
STP pre-test	A	30	74.71	4.93	0.06
	B	30	69.87	11.63	
STP post-test	A	30	67.50	4.62	0.55
	B	30	67.11	4.01	
CD pre-test (steps/min)	A	30	61.13	13.78	0.25
	B	30	67.43	21.44	
CD post-test (steps/min)	A	30	72.43	12.59	0.38
	B	30	72.80	19.26	

Group A – PNF based gait training plus routine physical therapy, Group B – gait training plus routine physical therapy, BBS – Berg balance scale, SWP – % swing phase, STP – % stance phase, CD – cadence

Table 3. Comparison of stride length, ambulation time, step length and velocity after intervention within groups (normally distributed variables). Paired samples statistics

Group, Variables			Mean	*N*	*SD*	*p*-value
A	SL (cm)	Before intervention	65.78	30	17.68	< 0.001
		After intervention	89.91	30	9.88	
	AT (s)	Before intervention	12.82	30	5.15	< 0.001
		After intervention	9.90	30	4.69	
	STL (cm)	Before intervention	33.17	30	8.17	< 0.001
		After intervention	44.68	30	4.93	
	V (cm/s)	Before intervention	42.75	30	17.59	< 0.001
		After intervention	68.79	30	15.29	
B	SL (cm)	Before intervention	70.29	30	19.85	< 0.001
		After intervention	90.82	30	9.68	
	AT (s)	Before intervention	11.77	30	5.26	< 0.001
		After intervention	10.05	30	5.29	
	STL (cm)	Before intervention	34.99	30	9.86	< 0.001
		After intervention	45.30	30	5.05	
	V (cm/s)	Before intervention	48.24	30	23.65	< 0.001
		After intervention	63.27	30	18.46	

Group A – PNF based gait training plus routine physical therapy, Group B – gait training plus routine physical therapy, SL – stride length, AT – ambulation time, STL – step length, V – velocity

Table 3 shows comparison of gait parameters before and after interventions within groups.

Table 4 shows comparison of balance and gait parameters before and after interventions, within both groups. On the basis of *p*-values ($p \leq 0.001$), it is observed that there was a significant difference between BBS, % of swing and stance phase and cadence before and after intervention within both groups.

Table 5 shows comparison of gait parameters pre-test and post-test between group A and group B. On the basis of *p*-values (as *p*-values are greater than 0.05), it was observed that no significant difference was seen in stride length, ambulation time, step length and velocity after interventions between both groups.

Discussion

This study compared the effectiveness of gait training plus routine physical therapy with and without PNF on balance and gait in chronic stroke patients. Clinical and demographic characteristics of participants of both groups were quite similar, which shows that both the groups were comparable (Table 1). The results of this study showed significant improvements in balance, stride length, step length, % swing phase, cadence and velocity of chronic stroke patients, while % stance phase and ambulation time were significantly decreased within both groups (Table 3 and 5). Balance improvement was more significant in PNF group as compared to the group without PNF (Table 4), which proves that PNF is more effective in enhancing the balance capabilities of post stroke individuals as compared to routine physical therapy alone.

This study showed a significant post-intervention improvement in BBS scores of the PNF group as compared to

Table 4. Comparison of balance, % of swing phase, % of stance phase and cadence within groups before and after interventions (not normally distributed variables). Paired samples statistics

Group, Variables			Mean	*N*	*SD*	*p*-value*
A	BBS	Before intervention	32.40	30	4.54	< 0.001
		After intervention	40.57	30	3.83	
	SWP	Before intervention	25.29	30	4.94	< 0.001
		After intervention	32.49	30	4.62	
	STP	Before intervention	74.71	30	4.93	< 0.001
		After intervention	67.50	30	4.62	
	CD (steps/min)	Before intervention	61.13	30	13.78	< 0.001
		After intervention	72.43	30	12.59	
B	BBS	Before intervention	32.07	30	4.37	< 0.001
		After intervention	38.37	30	4.03	
	SWP	Before intervention	27.44	30	4.52	< 0.001
		After intervention	32.88	30	4.01	
	STP	Before intervention	69.87	30	11.63	< 0.001
		After intervention	67.11	30	4.01	
	CD (steps/min)	Before intervention	67.43	30	21.44	< 0.001
		After intervention	72.80	30	19.26	

Group A – PNF based gait training plus routine physical therapy, Group B – gait training plus routine physical therapy, BBS – Berg balance scale, SWP – % swing phase, STP – % stance phase, CD – cadence (steps/min)
* Wilcoxon Signed Ranks Test
p-value < 0.001 in group A and group B shows that there is a significant difference between stride length, ambulation time, step length and velocity after interventions within both groups.

Table 5. Comparison of stride length, ambulation time, step length and velocity before and after interventions between group A and group B (normally distributed variables)

Variables	Group	*N*	Mean	*SD*	*p*-value
SL pre-test (cm)	A	30	65.79	17.68	0.36
	B	30	70.29	19.85	
SL post-test (cm)	A	30	89.92	9.88	0.72
	B	30	90.82	9.68	
AT pre-test (s)	A	30	12.82	5.15	0.44
	B	30	11.78	5.26	
AT post-test (s)	A	30	9.90	4.69	0.91
	B	30	10.05	5.29	
STL pre-test (cm)	A	30	33.17	8.17	0.44
	B	30	34.99	9.86	
STL post-test (cm)	A	30	44.69	4.93	0.63
	B	30	45.30	5.05	
V pre-test (cm/s)	A	30	42.75	17.59	0.31
	B	30	48.24	23.65	
V post-test (cm/s)	A	30	68.79	15.29	0.21
	B	30	63.27	18.46	

Group A – PNF based gait training plus routine physical therapy, Group B – gait training plus routine physical therapy, SL – stride length, AT – ambulation time, STL – step length, V – velocity

the non-PNF group (Table 4). The clinical interpretation of this finding is that the PNF techniques and principles are very effective when incorporated into routine physical therapy and gait training. This is in accordance with the clinical trial performed by Seo and Kim [17] in which PNF along with stair gait training was performed with stroke individuals, which resulted in increased Berg balance scores and functional reach test scores, while the decrement in time up and go (TUG) test scores resulted in significant improvements in balance and mobility. Similarly it can be clearly seen that PNF exercises using sprinter and skator also improves balancing capabilities and gait pattern in the post stroke population [18] that is also comparable with the results of the current study.

In this study, values of stride length, step length, cadence and velocity are significantly increased while that of ambulation time and % stance phase significantly decreased within both groups (Table 3 and 5), a lot of literature is present in support of the importance of PNF in enhancing gait quality, and consistency can be seen between findings of this study with the published literature that supports the use of PNF techniques, patterns and principles in improving gait, balance, functionality, ambulation and life quality among individuals with stroke [19]. PNF along with taping resulted in significant improvement in patient cadence, speed, and stride length [20]. The functional ambulation status of stroke survivors was also been increased by using PNF patterns [21]. The results of this study were also supported by another trial which shows the effectiveness of PNF pattern exercises under water in improving balance and ADLs of post stroke individuals [22].

In this study, there was no statistically significant difference observed in the values of stride length, step length, cadence, velocity, ambulation time, % of stance and swing phase between both groups (Table 2 and 4), this shows the equal effectiveness of both the PNF approach and routine physical therapy treatment protocols in enhancing the gait parameters of the participants. This showed a slightly different trend from the majority of the published literature, which mostly showed the importance of PNF over conventional physical therapy [9, 10]. However, a number of studies enforces the importance of conventional physical therapy treatment protocol in enhancing the ambulation and functional profile of post stroke individuals [11].

This study is limited in the fact that only one clinic in Lahore (Pakistan) was used to collect data. Involving multiple areas can yield different results. Patients were recruited by a non-probability convenient sampling technique that can be a cause of bias in the study results. This study did not document the physical activities of participants and adherence to the exercises at home.

Conclusions

Proprioceptive neuromuscular facilitation-based gait training along with routine physical therapy is more effective in improving static and dynamic balance as compared to routine physical therapy alone. However for improving gait parameters, PNF proves to be as effective as the routine physical therapy.

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Disclosure statements

No author has any financial interest or received any financial benefit from this research.

Conflict of interest

The authors state no conflict of interest.

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