RESEARCH

Proprioceptive Neuromuscular Facilitation Neck Pattern and Trunk Specific Exercise on Trunk Control and Balance—an Experimental Study

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Background: Most stroke survivors continue to live with disabilities and may require physical rehabilitation to control the trunk and balance during the post-stroke period. The cause of lack of trunk control and balance among stroke patients is the weakened trunk muscle strength.

Purpose: To study the effect of proprioceptive neuromuscular facilitation (PNF) neck pattern and trunk-specific exercise on trunk control and balance among stroke patients.

Setting: The study was conducted at the medical wards of Saveetha Medical College and Hospital, Chennai, India.

Participants: Sixty patients with stroke who met the inclusion criteria participated in the study.

Research Design: This is a quasi-experimental study.

Intervention: PNF trunk-specific exercise was administered to the experimental group for 45 min of 28 sessions, which contained 15 min of stretching exercise and 30 min trunk-specific exercise. The control group received routine hospital care services.

Main Outcome Measures: The study's primary outcome was balance and trunk control, measured by the Berg Balance Scale (BBS) and Trunk Impairment Scale (TIS) before the intervention and at the end of the intervention of 28 days.

Results: Within-group analysis, paired *t* test showed a significant improvement comparing the trunk control and balance score before (13.40±1.04 & 25.40±1.81) and after (15.03±0.96 & 27.07± 1.48) the intervention in the experimental group ($p < .001$). Between-group analysis, both the experimental and control group post-test mean score of TIS (15.03±0.96 &13.70±1.15) and BBS (27.07±1.48 & 25.30±1.73) showed significant difference ($p < .001$).

Conclusion: PNF neck pattern and trunk-specific exercise used in this study effectively improved balance and trunk control among patients with stroke.

KEY WORDS: balance; neck pattern; proprioceptive neuromuscular facilitation; stroke; trunk control; trunk-specific exercise

INTRODUCTION

Stroke is the critical and leading cause of premature death and disability in low-income and middle-income countries like India.(1) The neurological impairment of stroke may vary depending on the site of the vascular lesion, the length of time that perfusion was inadequate, and whether or not collateral circulation was present. As a result of these occurrences, numerous corporal areas may lose strength, sensitivity, ability to move, and control, resulting in speech abnormalities, loss of control of the anal and visceral sphincters, vision disturbances, and loss of balance or coordination.[2] Loss of trunk control which may limit the activities of daily living is commonly observed in patients with a stroke.[3] The cause of lack of trunk control and balance among patients with stroke is due to the weakened muscle strength of the trunk. Proprioception is also impaired in a large percentage, and is closely linked to control of movement following a stroke.[4,5] Trunk control is the ability of the trunk muscles to allow the body to remain upright, adjust to weight shift, maintain the centre of mass within the base of support during static and dynamic postural adjustments, and perform selective trunk movements.[6-8]

Dynamic activity and stability of the trunk require muscle strength, neural control, adequate flexibility, and proprioception.[9] Proprioception is the awareness of self-movement mediated by mechanosensory neurons located within muscles, tendons, and joints.[10,11] According to the National Stroke Association, 9 out of 10 survivors have some degree of paralysis or disability immediately following a stroke.[12] Majority of stroke survivors continue to live with disabilities, and the costs of ongoing rehabilitation and long-term care are primarily undertaken by family members, which ruin their families.[13] Regaining the control of the body's trunk is necessary to maintain the balance against gravity and prevent complications. Physical rehabilitation may help to control the trunk and balance during the post-stroke period. Various physical rehabilitation therapies are in practice to regain normal or near-normal function of the affected part, thereby minimizing the disability.

Proprioceptive neuromuscular facilitation (PNF) is a promising, more advanced form of flexibility training to improve trunk stability.[14] PNF is the neurophysiological approach in which impulses from the periphery are facilitated to the central nervous system through the stimulation of sensory receptors present in muscles and around the joints by stretch and resistance.[15] The muscle group is passively stretched and contracted isometrically against resistance. At the same time, it is in a stretched position during progressive stretching, which allows it to stretch further during subsequent exercise. Flexibility and range of movement may increase if exercise is done regularly.[16] PNF stimulates proprioceptors within the muscles and tendons, thereby improving functions and increasing muscle strength, flexibility, and balance in stroke patients.[17]

The potential ways for PNF to increase the range of motion is by the physiologic mechanism of autogenic inhibition, reciprocal inhibition, stress relaxation, and the gate control theory.[18] PNF also benefits individuals recovering from muscle damage, as well as for sporting activities to improve the body's ability to perform.[19] Moreover, this exercise does not require any equipment; however, it needs assistance and intensive supervision. The stability of the head and neck is known to improve by neck pattern exercises.[20] Soleus and quadriceps muscles get activated and strengthen the muscle power following the trunk stabilization using PNF exercises among patients with stroke.[21] Pyramidal tract and the brain's motor pathways may get excitable as the sensory input coming from the periphery was more significant during PNF.[22] It also helped to normalize the tone of affected side trunk muscles, lengthening the contracted structures, relaxing the hypertonic muscles, initiating the movements, strengthening the weak muscles, and improving the control of the pelvis.[23] There is evidence that trunk training exercises showed moderate evidence to improve trunk performance and dynamic sitting balance.[24-26]

Though the existing studies proved that trunk exercises were mediated by improved trunk control, the gap still limits the understanding of lower limbs for balance. The current study hypothesized that PNF neck pattern and trunk-specific exercise would significantly improve trunk control and balance.

METHODS

Participants

The Institutional Ethical Committee of Health Sciences under the Saveetha Institute of Medical and Technical Sciences approved a study (058/04/2021/IRB-HS/SIMATS dated 9 April 2021). The investigators explained the purpose of the study to the participants in their regional language and clarified any concerns. Written informed consent was obtained from the participants after assuring confidentiality. Patients who were medically diagnosed to have a mild stroke with balance problems and good cognition to follow the instruction were included in the study. The exclusion criteria were stroke patients with uncontrolled hypertension, fractures or orthopaedic surgeries, osteoporosis, spinal deformities like kyphosis, scoliosis and lordosis, chronic neck pain, severe depression and anxiety, and severe stroke patients.

Sample Size

The sample size was calculated by Sigma Plot 13 (Systat Software Inc., Palo Alto, CA). The sample size was estimated assuming a 20% improvement in the trunk control and balance with a 35% standard deviation, 90% power, 5% significance level, and 20% as drop out; the sample size was rounded off to 30 in each for the control and experimental group.

Study Design and Setting

The investigators adopted a quasi-experimental design to conduct the study at Saveetha Medical College and Hospital after obtaining formal permission from the hospital authority. The experimental group (n=30) and control group (n=30) were selected from I & II and III & IV units of both male and female Medical wards using the non-probability convenience sampling technique.

Outcome Measures

The primary outcome measures are trunk control and balance measured by the Berg Balance Scale (BBS) and Trunk Impairment Scale (TIS). Both scales are more valid and reliable for assessing balance and trunk control. The relative interrater reliability of the BBS and TIS was 0.97 and 0.98, respectively.

Berg Balance Scale (BBS)

Berg Balance Scale is designed to measure balance in a clinical setting among people with impairment in balance function by assessing their performance. The performance category was sitting balance, standing balance, and dynamic balance, with 14 items. Each item in the scale ranges from 0–4. “0” indicates the lowest level of function, and “4” indicates the highest level of function; the total score was 56 and interpreted as 41–56 is a low fall risk, 21–40 is a medium fall risk, and 0–20 is a high fall risk.

Trunk Impairment Scale (TIS)

TIS is a new tool to measure the motor impairment of the trunk after a stroke through the evaluation of static and dynamic sitting balance and coordination of trunk movement.[19] It has three subscales—static sitting balance, dynamic sitting balance, and coordination—and each subscale has three to 10 items. Scores range from a minimum of 0 to a maximum of 23. If patients score 0 on the first item, the total score on the TIS is 0. Three attempts were given for each item to perform, and the best performance score was recorded. The investigator provided the instruction verbally and non-verbally during the assessment. The scoring was interpreted as Normal (15–23 Score), Good (11–14 Score), Fair (8–10 Score), and Poor (1–7 Score).

Intervention Protocol

PNF trunk-specific exercise for 45 min included 15 min of stretching and 30 mins of trunk-specific exercise. It was designed to be administered for four weeks as the body needs six weeks maximum to adapt and bring the desired changes. It was administered by the investigators who had trained in the exercise.

Stretching exercise

The consists of a sequence of neck stretching of flexion, extension, posterior, lateral, rotation, upper back, and shoulder blade pull. It started with flexion neck stretch by tilting the head downwards until the patient could feel the back of the neck stretch. This was followed by tilting the head upward with the jaw closed and instructing the participants to feel the stretch in the front of the neck. Then, posterior neck stretch in which the participants were instructed to tuck the chin in, tilt the head down towards the chest, and simultaneously use another hand to apply pressure on the head if necessary. The exercise continued with rotation neck stretch by gently stretching the neck by looking over the right shoulder, holding for 10 sec, and then looking over the left shoulder for 10 sec. Applied stretch involved bringing one arm across the body, keeping the shoulder depressed, and pulling it in with the other arm. Shoulder blade pull stretch was given by assisting the participants in bending the raised arms at 90° while sitting and relaxing shoulders and neck.

Trunk specific exercise

The steps of trunk-specific exercise were flexion, extension, rotation, lateral flexion, and forward reach. Participants were assisted in flexing and extending the trunk while sitting with their feet on the floor. They followed this with clasping the hands and moving the hands toward left and right alternatively. Upper trunk lateral flexion initiates movement from the shoulder girdle and brings the elbow towards the plinth. The forward reach exercise was performed by asking the participants to reach a flexion point at the shoulder height from a sitting position.

Procedure

Demographic and clinical variables were collected using a structured questionnaire in the interview. Both groups assessed pretest on balance and trunk control using the Berg Balance Scale and Trunk Impairment Scale. The experimental group received the trunk-specific exercise for 45 min of 28 sessions, along with routine hospital care on a one-to-one basis. It was administered in the treatment room or at the bedside, depending on the participants' comfort during the intervention. Participants were also followed after discharge until to complete the 28 sessions of the interventions. Once the participant was discharged, from the next day onwards, the intervention continued at home during the evening. Out of 30 participants in the experimental group, four received six sessions at home, and two received eight sessions at home after getting discharged, with 22 and 20 sessions in the hospital. The participants were observed for progress and any untoward effects during an intervention. The control group received routine care at the hospital. Post-test assessment of balance and trunk control was done using the same tool at the end of one month for both experimental and control groups. Blinding for measuring outcomes by the investigators was not done. The participants in the experimental group were monitored during intervention for any untoward reaction; however, no adverse effect was reported throughout the study. The ethical principles were adhered to protect the rights of the samples and maintained confidentiality throughout the study.

Analysis

The data were analyzed by descriptive and inferential statistical methods using SPSS statistical package (IBM SPSS Statistics, Armonk, NY). The demographic and clinical variables were described as frequency and percentage. The effectiveness of intervention within the group was calculated by paired *t* test, and the effect of intervention between the experimental and control group was compared by unpaired *t* test. A chi-square test was used to associate the post-test level of trunk control and balance control with the selected demographic and clinical variables. The probability of $p < .05$ or less was taken as statistically significant.

RESULTS

The total number of participants screened according to the inclusion criteria was 60 and were allocated into the experimental group (n=30) and control group (n=30). The demographic and clinical variables were expressed as frequency and percentage. Table 1 shows that in the experimental group, 11 (36.7%) were aged between 51 and 60 years, and 23 (76.7%) were male. Regarding clinical variables, 22 (73.3%) had an acute stroke due to ischemia; equally, 50% had affected the right and left hemispheres of the brain with involvement of the right- and left-middle cerebral artery each. Accordingly, in the control group, 10 (33.4%) were aged between 40 and 45 years, 22 (73.3%) were male, 21 (70%) had an ischemic stroke, 26 (86.7%) had an acute stroke, and the majority (73%) had affected in the right hemisphere of the brain with right mid-cerebral artery involvement.

Table 2 shows that, out of 30 participants in the experimental group, 25 (83.33%) had good trunk control and 5 (16.67%) had normal trunk control in the pre-test. In the post-test, 20 (66.67%) had normal trunk control, and 10 (33.33%) had good trunk control. In the control group, 24 (80%) had good trunk control and 6 (20%) had normal trunk control in the pre-test, and in the post-test, 23 (76.67%) had good trunk control and 7 (23.33%) had good trunk control. Regarding balance control, all 30 (100%) had a medium risk of falls in both the pre-test and post-test of the experimental group and the control group. Regarding balance, though all 100% were under the category of medium risk of fall in pre-test and post-test of experimental and control groups, there were changes in the scoring as medium risk of fall score ranges from 21–40.

TABLE 1. Baseline Outcome Measures

Demographic Variables	*Experimental Group*		*Control Group*	
	No.	*%*	*No.*	*%*
Age in Years				
40–45	7	23.3	10	33.4
46–50	6	20.0	7	23.3
51–60	11	36.7	7	23.3
61–65	6	20.0	6	20.0
Gender				
Male	23	76.7	22	73.3
Female	7	23.3	8	26.7
Occupational Status				
Private	7	23.3	8	26.7
Unemployment /Housewife	6	20.0	6	20.0
Business / Self employed	4	13.3	6	20.0
Agriculture	10	33.4	9	30.0
Retired	3	10.0	1	3.3
Clinical Variables				
Types of Stroke According to Cause				
Ischemic stroke	22	73.3	21	70.0
Hemorrhagic stroke	8	26.7	9	30.0
Types of Stroke According to the Duration				
Acute stroke	22	73.3	26	86.7
Sub-acute stroke	8	26.7	4	13.3
Duration of Stroke Since				
< 3 months	6	20.0	9	30.0
4–6 months	15	50.0	12	40.0
7 months to 1 year	9	30.0	9	30.0
Part of Brain Affected				
Right hemisphere	15	50.0	22	73.3
Left hemisphere	15	50.0	8	26.7
Arteries Involved				
Right mid-cerebral artery	15	50.0	22	73.3
Left mid-cerebral artery	15	50.0	8	26.7

TABLE 2. Comparison of TIS Score

TIS[a]	Poor (0–7)		Fair (8–10)		Good (11–14)		Normal (15–23)	
	No.	%	No.	%	No.	%	No.	%
Experimental Group								
Pre-test	0	0	0	0	25	83.33	5	16.67
Post-test	0	0	0	0	10	33.33	20	66.67
Control Group								
Pre-test	0	0	0	0	24	80	6	20.0
Post-test	0	0	0	0	23	76.67	7	23.33

[a]TIS = Trunk Impairment Scale; described in terms of frequency and percentage.

Within group analysis, paired *t* tests compared the experimental group's pre-test and post-test levels of trunk control and balance. The experimental group pre-test and post-test mean trunk control and balance score was 13.40, 15.03, 25.4, and 27.07, respectively. The calculated value of $t = 14.548$ and $t = 8.601$ was statistically highly significant at a $p < .001$ level (Table 3).

In between group analysis, the post-test mean and standard deviation of trunk control in the experimental and control group was 15.03±0.96 and 13.70±1.15, whereas it was 27.07±1.48 and 25.30±1.73 in balance control in TIS and BBS outcome measured post four weeks of intervention.

The results demonstrated that the calculated independent *t* test value of $t = 4.868$

TABLE 3. Within-Group Analysis of Experimental and Control Group

S. No	Parameter	Group	Mean ± SD	Paired t test: Control Pre – Post	Paired t test: Experimental Pre – Post
1.	TIS	Control Pre-test	13.65±1.12	$t = 8.651$ $p = .18$ NS	$t = 14.548$ $p = .0001$[a] S
		Control Post-test	13.70±1.15		
		Experimental Pre-test	13.40±1.04		
		Experimental Post-test	15.03±0.96		
2.	BBS	Control Pre-test	25.17±1.69	$t = 3.562$ $p = .12$ NS	$t = 8.601$ $p = .0001$[a] S
		Control Post-test	25.30±1.73		
		Experimental Pre-test	25.40±1.81		
		Experimental Post-test	27.07±1.48		

[a]P values are reported using paired *t* test for TIS and BBS.

S = significant; NS = not significant; TIS = Trunk Impairment Scale; BBS= Berg Balance Scale.

and $t = 4.252$ was statistically highly significant at $p < .001$ (Table 4). The effect size of trunk control and balance between the experimental and control group was 1.39 and 1.20 which shows the large effects and practical significance. This finding represents that PNF neck pattern and trunk-specific exercise administered to the patients with stroke in the experimental group were more effective in improving the level of trunk control and balance control than those with stroke in the control group. There was zero attrition rate due to high compliance towards exercise, and no harmful untoward adverse events occurred during the study period.

DISCUSSION

The motor impairment can be caused by a cerebrovascular accident that affects the motor neurons. Trunk control and balance are important functional outcomes after stroke, and the same deteriorates the body following a stroke. The therapeutic goal of stroke management is to facilitate an optimal structural and neuromuscular state based on the stimulation of proprioceptors. In the present study, the motor function was assessed regarding trunk control and balance. The study findings show the impairment in trunk control and balance in both experimental and control groups. All 60 participants had a medium risk for falls in the pre-test assessment. Most (80%) of them had an acute stroke due to the involvement of the right mid-cerebral artery and were in the acute stage of stroke. As trunk muscles are primarily contributed to the stabilization of the head and trunk, the current study intensively investigated the impact of PNF neck pattern and trunk-specific exercise. The study found a significant improvement in both trunk and balance control in the experimental group after the administration of PNF neck pattern and trunk-specific exercise. It was also found that there were only positive changes in the control group due to the routine treatment protocol; however, it was not statistically significant.

This present study finding is supported by Hwangbo and Kim who concluded that PNF neck pattern exercise was shown to have a positive effect on the ability to control the trunk and maintain balance in chronic stroke patients.[27] In the current study, none were in the chronic stroke. Similarly, another study by An and Park proved that there is an improvement in mobility, balance, and trunk control in chronic stroke patients through selective trunk exercise with a neural development program.[28] A systematic review and meta-analysis of randomized controlled trials on trunk training by Van Criekinge et al. revealed a strong amount of evidence showing that trunk training can improve trunk control mobility and sitting and standing balance.[29] A study by Kim et al. demonstrated that underwater coordination movement using the PNF pattern significantly affects stroke patients' balance and gait.[30] According to the study finding of Lee et al., the PNF gait training program helps enhance the adaptation of the gait and balance in a single subject design.[31] A similar finding was reported by Chithra and Joshi that PNF techniques benefit the hemiplegic population's trunk control and quality of life.[32] The gait training group to which PNF was applied saw improvements in their balance ability than the control group in the study by Seo et al.[33] The present study findings also observed the difference in post-test mean value between the experimental and control groups. It also proved a difference and significant improvement in the experimental group who had undergone PNF neck pattern and trunk-specific exercise than the control group. The participants in the experimental group became comfortable and practiced. It was also observed that this exercise was safe as it did not cause adverse effects during the study period.

Table 4. Between Experimental and Control Group Analysis

	Mean± S.D	*Mean Difference Score*	*Unpaired t Test*
TIS			
Experimental	15.03±0.96	1.33	$t = 4.868$ $p = .0001^a$ S
Control	13.70±1.15		
BBS			
Experimental	27.07±1.48	1.77	$t = 4.252$ $p = .0001^a$ S
Control	25.30±1.73		

[a]P values are reported using paired *t* test for TIS and BBS.

S = significant; NS = not significant; TIS = Trunk Impairment Scale; BBS= Berg Balance Scale.

A study by Park and Moon reported that change in chair heights during trunk stability exercise using PNF was effective in bringing desirable changes in gait velocity, cadence, and stride length on the affected side of the body.[34] The current study does not observe the gait cycle and stance phase on the affected side as well as muscle strength and physical performance tasks. Very recently, Khallaf found that task-specific training effectively improves the static and dynamic postural control and trunk range of motion among sub-acute stroke patients.[35] Desai et al. conducted a study to evaluate the relationship between trunk impairment and gait in patients with a cerebrovascular accident and showed a highly significant correlation between trunk impairment and gait in subjects.[36]

The minimal clinically significant difference score of the BBS and TIS was 13.4 and 14.5, which denotes the perceived benefits of PNF trunk-specific intervention by the participants. It also determined clinically essential changes in TIS and BBS among patients with stroke in response to PNF neck pattern and trunk-specific exercise. The significance of this study complements the medical intervention and renders the comprehensive care for the patients with stroke in clinical and community areas. It also motivates the researchers to conduct more extensive research and utilize this finding in today's clinical practice. In the future, the same study can focus on a large number of samples with a more extended intervention period. It can also be intervened for the upper and lower extremity motor functions. The present study suggested that conducting the PNF exercise with the different functional tasks is an adequate trunk and balance control and also assesses the quality of life, and gait, of the patients with stroke as this study is limited to the trunk and balance control. It also found that this exercise was very safe as it did not cause adverse effects during the study period. PNF neck pattern and trunk-specific exercise can be compared with other exercise or rehabilitation programs, such as acute and chronic stroke, to determine the reliability and generalize the study findings.

CONCLUSION

The present study's findings concluded that PNF neck pattern and trunk-specific exercise effectively improve balance and trunk control among patients with stroke. Hence, this exercise can be incorporated into the routine treatment protocol, and utilized to enhance balance and trunk control, minimizing disability and improving quality of life.

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CONFLICT OF INTEREST NOTIFICATION

The authors declare there are no conflicts of interest.

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