Enhancing trunk stability in acute poststroke subjects using physioball exercise and proprioceptive neuromuscular facilitation technique: A pilot randomized controlled trial

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ABSTRACT

Background: Stroke is one of the leading causes of death and disability worldwide. Poststroke, most survivors experience trunk control impairment and instability. Previous works on exercise on an unstable surface to improve trunk stability in nonstroke population had proven effective. Thus, physioball exercises (PBEs) in poststroke subjects may be useful in the recovery of trunk stability and thereby reduce disability. We hypothesize that PBE is feasible and effective in enhancing trunk stability. Aims: To test the feasibility and successful implementation of conducting a randomized controlled study to assess the clinical effectiveness of PBE and proprioceptive neuromuscular facilitation (PNF) technique to enhance trunk control in poststroke subjects. Methods: This study was conducted in a stroke unit of Global Hospitals and Health City, Chennai, India. Thirty patients with the first onset of stroke within 40 days of stroke duration, lesion to one side, and ability to sit independently with or without arm support for 15 days were recruited. All thirty poststroke subjects were randomized either into PBE group or PNF group, and outcome assessors involved in the trail were blinded to allocation. PBE group performed task-oriented activities on an unstable surface and PNF group were treated with PNF-specific trunk stability exercise program for 4 weeks (30 min/day, 5 times/week). Trunk impairment scale (TIS) was used as a main outcome measure. Results: Data were analyzed using Wilcoxon signed rank sum test and Mann–Whitney U-test for intra- and inter-group comparison. The baseline characteristics between both groups were statistically nonsignificant. Within groups, there were significant improvements between baseline and at 4 weeks in the measure of TIS. In addition, PBE group showed a significant increase in trunk control (mean 2.33, 95% confidence interval 1.14-3.52, \( P = 0.002 \)) than the PNF subject. Conclusion: This pilot randomized controlled trial (RCT) showed the potential efficacy of PBE in developing more trunk stability than PNF in poststroke subjects. The current study had proved the feasibility of undertaking a large-scale RCT. Since this is a pilot study to establish any sort of conclusive evidence on the efficacy of PBEs in the poststroke population, a larger sample-sized trial is needed.

Key words: Hemiplegia, physioball, proprioceptive neuromuscular facilitation

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INTRODUCTION

Stroke is the leading cause of morbidity and mortality in adult population worldwide. According to the World Health Organization, about 15 million people suffer stroke worldwide each year. Among those, 5 million die and more than 5 million are permanently disabled. More than 30% of stroke survivors are permanently disabled and require partial to total assistance to perform their daily activities. An estimation of the prevalence of stroke in India ranges from 44 to 843/100,000 population. South Asian countries, on the one hand, have a very high stroke population and on the other hand, are limited by stroke rehabilitation specialists and financial resources. The most typical symptom of stroke is hemiparesis or hemiplegia, which ranges from weakness to full paralysis of the body opposite to the side of the supratentorial lesion. Stroke survivors commonly have impaired motor control and balance that seriously affect their ability to lead an independent life and increasing burden to carers and society. Impaired postural control mechanism due to lack of interaction between motor, sensory, and cognitive functions is the major cause of trunk control impairments.

In addition to limb muscles, trunk musculature is also impaired in stroke patients. Trunk muscles play an important role in the support of our body in antigravity postures such as sitting, standing, and in the stabilization of proximal body parts during voluntary limb movements. Hemiplegic subjects have difficulty to move their trunk in relation to gravity, regardless of what type of muscle activity is required. The absence of proximal stabilization (trunk) profoundly influences the limbs, hence the upper and lower limbs can be moved only in spastic synergy and the distal spasticity is further increased as the subject attempts to compensate the loss of attachment when it attempts to move against gravity. Good trunk stability is essential for balance and extremity use during daily functional activities. Previous studies have identified deficits of trunk muscle strength and poor trunk control in poststroke subjects. Poor recovery of trunk muscle performance results in a severe disability and a reduction in the activities of daily living (ADL). Trunk control is an integral part of postural control. Altered trunk control leads to postural instability and disequilibrium, which delays the recovery of gait and functional independence. In stroke rehabilitation, trunk muscle performance is an important factor in predicting the functional outcome.

Proprioceptive neuromuscular facilitation (PNF) is one of the well-established treatment techniques incorporating functional diagonal movement patterns in the rehabilitation of stroke subjects. PNF techniques focus on the stimulation and facilitation of proprioceptors to increase demand on the neuromuscular mechanism to obtain and simplify their responses. Despite the fact that PNF techniques are more commonly employed in poststroke rehabilitations, most of the studies report its efficiency on upper extremity functions. At the same time, studies on nonstroke population using exercises on unstable surfaces such as physioballs have proven to improve the activation of trunk musculature by virtue of postural perturbation.

Hence, the prospect of physioball exercises (PBEs) being beneficial in improving trunk stability in poststroke should be explored. Recent studies had reported on the efficacy of neurodevelopmental treatment, motor re-learning program, strengthening exercises in improving upper extremity functions, and gait. However, evidence to showcase the comparative efficacy of conventional intervention tools to improve trunk control and stability in poststroke are scarce. The primary purpose of this pilot study is to assess the potential for successful implementation of a randomized controlled trial (RCT) to compare the effectiveness of PBE versus PNF program in improving trunk stability among acute poststroke subjects. We hypothesize that PBE is feasible, safe, and potentially efficacious in enhancing trunk stability.

METHODS

Study period, design, and oversight
This is a pilot study, randomized controlled, single-blinded trial, performed at the neurological rehabilitation center of the inpatient stroke unit, Global Hospitals and Health City, Chennai, India, during February 2015 to July 2015. The local Institutional Ethical Review Board of Madha College of physiotherapy has approved the protocol, and all participants provided thumb impression or written consent to participate in this study. A set of neurologist and physician helped the investigators in medical and safety monitoring, medical stableness, and diagnostic featuring of the stroke subjects. Diagnosis was confirmed by clinical examination and computed tomography scans or magnetic resonance imaging. The authors vouch for the completeness and accuracy of the data and attest to the reliability of the report to the study protocol. No grant or commercial support was received for the study.

Study population, screening, and randomization
From 91 stroke patients admitted during our study period, seven expired during the recruitment process and 54 of them did not meet our recruitment criteria. Thirty stroke survivors admitted to a single center inpatient rehabilitation unit and referred from the department of neurology, who meet the requirements were recruited for this RCT [Figure 1]. The criteria for inclusion in the study were age between 18 and 65 years,
a stroke within 40 days before entry in the study, first episode of stroke, clinical manifestations lasting >24 h, ability to undergo randomization within 60 days poststroke, scoring more than 48 in trunk control scale[14,15] score of over ≥23 points, and 2 or less in modified Ashworth scale.[16] Primary criteria for exclusion were active cardiovascular disease (American Heart Association class 3 or above),[16] contraindications to exercise, preexisting neurological disorders, severe communication impairments, a body mass index >31 kg/m², and history of diagnosed musculoskeletal disorders. Eligible stroke patients underwent physical and cognitive screening, and their medical records were reviewed.

After baseline data collection [Table 1], patients included in the study were randomly assigned to unstable surface exercise group, i.e., PBE group (n = 15) or PNF group (n = 15). Randomization scheme was generated by custom-made software by an independent statistician. The randomized list was not known to anyone in the study. An opaque envelope containing specific treatment was given to the patient on inclusion and the treating physical therapist opened the envelopes at the start of the treatment and informed the patients of their treatment group. Each subject had an equal probability of being assigned to either group.

### Table 1: Characteristics of the participants

| Category | PBE group (n = 15) | PNF group (n = 15) |
|----------|--------------------|--------------------|
| Age (years; mean±SD) | 49.2±4.3 | 51.1±5.4 |
| Height (cm) | 163±9 | 161±7 |
| Weight (kg) | 66±8.3 | 69±10.1 |
| Gender (%) | | |
| Male | 11 (36.7) | 9 (30) |
| Female | 4 (13.3) | 6 (20) |
| Side of lesion (right/left) (%) | 7 (23.3)%/8 (2.7) | 10 (33.3)%/6 (16.7) |
| Time from stroke to randomization days (%) | 21±10.4 | 23±6.7 |
| Etiology (%) | | |
| Ischemic | 11 (36.67) | 9 (30) |
| Hemorrhage | 4 (13.33) | 6 (20) |
| Clinical syndromes (%) | | |
| TACS | 3 (10) | 2 (6.67) |
| PACS | 6 (20) | 8 (26.67) |
| LACS | 4 (13.33) | 4 (13.33) |
| POCS | 2 (6.67) | 1 (3.33) |
| MMSE | 27.5±2.0 | 28±1.4 |

Values are expressed as mean ± SD or n (%), Etiology is also expressed as a percentage of the total number of patients, TACS: Total anterior circulation stroke, PACS: Partial anterior circulation stroke, LACS: Lacunar stroke, POCS: Posterior circulation stroke, MMSE: Mini-mental state examination, SD: Standard deviation, PNF: Proprioceptive neuromuscular facilitation, PBE: Physioball exercise

### Intervention

All patients included in the study received conventional acute phase physical therapy management for their upper and lower extremities in addition to their corresponding trunk exercise based on the group they belong; for 1 h and 30 min with a rest period of 10 for every 30 min set a day, 5 days a week.

### Experimental Group I (physioball exercise)

Supine exercise; pelvic bridging was performed by placing both the subject’s legs on a physioball and asking him or her to lift the pelvis off the support surface. Initially, the ball was kept beneath the knees and advanced to the lower leg. The exercise intensity was further increased by flexing the uninvolved upper limb. The unilateral pelvic bridge was performed by lifting the uninvolved leg off the ball while maintaining the pelvic bridge position. Upper trunk rotation was performed by having the subject rest his or her trunk on the ball with the knee flexed at 90° and the feet flat on the support surface. The subject was asked to perform a task-specific reach out for an object kept above the hip by a flexion-rotation of the upper trunk. Lower trunk rotation was performed by placing both legs of the subject on the ball and asking him or her to move the ball to both left and right by rotating the pelvis. Initially, the ball was placed beneath the knees and then advanced toward the ankle.

Sitting exercise; subject was seated on the physioball with hips and knees flexed to 90° and the feet positioned
flat on the floor. Flexion–extension of the lower trunk was performed by anteflexion and retroflexion of the lower part of the trunk. Upper trunk lateral flexion was performed by initiating movement from the shoulder girdle so as to bring the elbow toward the ball. Lower trunk lateral flexion was achieved by initiating movement from the pelvic girdle so as to lift the pelvis off the ball and bring it toward the rib cage. Upper trunk rotation was performed by moving each shoulder forward and backward. Lower trunk rotation was performed by moving the knees forward and backward, and weight shifting was executed by letting the ball roll forward until it touched the back of the legs, thereby allowing the lower spine to curve, followed by rolling the ball backward and allowing the lower spine to arch.

**Experimental Group II (proprioceptive neuromuscular facilitation)**

In this group, subjects received PNF pattern for trunk as follows: Bilateral upper extremity pattern for trunk by chopping/lifting, bilateral lower extremity pattern for trunk, trunk lateral flexion, combination patterns for the trunk by upper and lower trunk flexion, upper trunk flexion with lower trunk extension, upper and lower trunk extension, and upper trunk extension with lower trunk flexion.

The amount and intensity of exercise in both the groups at each session were graded according to each subject’s functional ability, with 2 min rest in between. Progression was made by increasing the repetition, resistance, and change in positioning (from supine to sitting) according to the individual’s ability.

**Outcome measures**

Trunk impairment scale (TIS) was the outcome tool used to measure trunk control and functional balance in subjects with stroke. Baseline demographic data including name, age, gender, date of stroke onset, and medical history were collected. All subjects received an initial and a final assessment session. The TIS is a 2-, 3-, or 4-point ordinal scale which evaluates static sitting balance, dynamic sitting balance, and coordination. The observers who measured the outcome were not aware of the group allocations.

**Statistical analysis**

Data were analyzed using the SPSS version 20.0 statistical package (IBM Armonk, NY, United States of America).

| Trunk impairment scale score | Pretest | Posttest | Mean difference | Wilcoxon signed rank test (Z) | P   |
|-----------------------------|--------|---------|----------------|-----------------------------|-----|
| Total trunk control         |        |         |                |                             |     |
| PBE group (n=15)            | 13.33 (1.39) | 20.20 (2.47) | 6.87          | 3.45                        | 0.0012* |
| PNF group (n=15)            | 14.60 (1.95) | 19.13 (2.23) | 4.53          | 3.46                        | 0.0012* |

Values are presented as mean (SD), *Significant difference in P < 0.05. SD: Standard deviation, PNF: Proprioceptive neuromuscular facilitation, PBE: Physioball exercise.

The comparison of baseline characteristics between the groups such as age, gender, poststroke duration, hemiplegic side, and type of stroke was analyzed by descriptive statistics. Statistical analysis was analyzed using Wilcoxon signed rank sum test and Mann–Whitney U-test for intra- and inter-group comparison. The mean differences and 95% confidence intervals (CI) (95%) were calculated for the PBE and PNF groups. The level of significance was set at 0.05.

**RESULTS**

**Demographics**

The baseline characteristics were similar in the PBE group and PNF groups, suggesting the effective randomization procedure. Mean age of subjects in PBE group and PNF group was 49.2 ± 4.3 and 51.1 ± 5.4, respectively. Description of height, weight, gender, side, and etiology is presented in Table 1.

**Trunk impairment scale**

Intragroup comparison of PBE group in total trunk control scale shows that the mean difference was 6.86 with Wilcoxon signed rank test with a Z value of 3.45 and had a significant P value of 0.0012 [Table 2]. Intragroup comparison of PNF group for total trunk control in TIS shows that the mean difference was 4.53 with a Z value of 3.46 and P value of 0.0012, which was found to be statistically significant [Table 2].

Further, between-group comparison of the pre- and post-treatment changes showed that subjects in the PBE group had more increase and developed better trunk control (mean 2.33, 95% CI 1.14–3.52, P = 0.002) than the PNF subjects [Table 3].

The low P values suggest that there is enough evidence to say that PBE group experienced a higher control of functionality in the trunk, which will eventually reflect in increased ability to perform ADLs and increased functional independence, since the trunk forms the base for a greater number of ADLs.

**DISCUSSION**

Recovery of trunk control or proximal stabilization is an essential part of rehabilitation program, since it is...
associated with a dramatic improvement of functional autonomy. In this clinical study, intervention of poststroke subjects on unstable surfaces such as physioball showed potentials of improvement in trunk stability than PNF technique interventions. The PBE group experienced 52% postintervention improvement when compared to 31% improvement shown by the PNF group using primary outcome tool; TIS, which measured static sitting balance, dynamic sitting balance, and coordination. The PBE group had a better recovery after 20 sessions of training on an unstable surface. Nevertheless, we endorsed the better improvements in trunk control of the PBE group to factors such as performing exercises on physioball, which is a liable surface demands multi-directional and greater challenge from trunk musculature, and exercising on unstable surfaces would also place substantial biomechanical and coordination demand on the trunk of poststroke subjects. In previous studies, implementation of PBEs as an intervention to improve trunk stability and balance in other health conditions have been successful. On the other hand, the PNF group in this study also experienced improvement, which also explains and adds to the evidence of previous studies on stroke survivors. However, the fact that PNF techniques imposed application challenges such as poor patient understanding and lack of available expertise for all patients which may have also contributed to the results and the same have been reported by previous studies. On the other hand, in this trial, PBE increased voluntary participation, improved patient’s adherence vowing to the entertainment it offers, and demands minimum understanding, especially from patients of upper motor neuron lesion patients.

To the best of our knowledge, the strength of this pilot trial is this study is the first attempt to explore the efficacy of unstable surface exercise in improving trunk stability in poststroke. The results of this pilot study also suggest that PBE represents a effective alternative treatment to improve trunk stability in poststroke subjects. Limitations of this study are that this is just a pilot study with limited sample size; on the other hand, this study should suffice to estimate the necessary sample size for the large scale study. In addition, this pilot trial did not attempt to record follow-up effects after nonintervention period to address the retention of intervention effects.

### Clinical implication and future research

The findings of this study indicate improvement in trunk control of poststroke subjects with PBE. Future studies with larger samples and follow-up of the patients are needed to support our study results.

### CONCLUSION

This study showed that the PBE is potentially effective for functional rehabilitation of the trunk among hemiplegic subjects and PNF may be an alternative complementary therapy to the PBE in improving trunk control. The patients in PBE also reported having had more fun and challenge during the treatment. However, interpretations of this study results should be taken carefully considering the characteristics of our sample. To estimate the required sample sizes required to detect these effects in a larger scale trial, G*power was used; sample sizes varied from n = 102 to n = 230. Allowing 20% nonresponse rate, this would mean a sample size of n = 276 poststroke patients would be large enough to detect the effects found in the current study. Our next step is, therefore, to confirm this effect in an adequately powered RCT.

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### Conflicts of interest

There are no conflicts of interest.

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