Journal of Exercise Science & Physiotherapy Vol.17 No.2 (July to December) 2021
ISSN: 0973-2020 (Print) I2OR Impact Factor = 7.005 ISSN: 2454-6089 (Online)

Effects of Exercise Protocol for Facilitation of Trunk Control and Improve Balance in Stroke Patients

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Abstract

Aim: To find out effect of pelvic Proprioceptive Neuromuscular Facilitation along-with Star Excursion Balance Test grid on trunk control and balance in stroke patients. **Material and Method**: A two group, pre-test, post-test structured, experimental study design. A total of 38 patients amongst the sub-acute and chronic hemi paretic stroke patients, age group between 40 to 60 yrs; both male & female; duration of 3 to 12 months; ambulatory patients only with or without walking aids; scoring less than or equal to 21 out of 23 on Trunk Impairment Scale; without any fixed hip, knee and ankle deformity; could able to stand independently for 90 seconds on a stable surface were recruited randomly. Group 1 (Experimental group) – 19 subjects, group 2 (Conventional group) – 19 subjects. Group – 1 (Experimental group) – 19 subjects with a mean age of 47.21±8.20 (yr) and mean duration of 0.68±0.42 (yr) performed SEBT training and Pelvic PNF for 20 minutes a day, along with conventional trunk exercises performed on plinth. Group – 2 (Conventional group) – 19 subjects with a mean age of 52.47 ±7.96 (yr) and mean duration of 0.78±0.38 (yr) performed conventional trunk exercises on plinth. Duration of exercise session is 30 minutes/ day, five times a week, for four weeks duration. Measurements were taken for Trunk Impairment Scale (TIA) and Tinetti Balance Assessment (TBA) to document gait parameters and balance prior to the beginning of treatment and were repeated finally after the completion of 4 weeks of treatment protocol. The dependent variables were analyzed using a 2X2 ANOVA, repeated measures on second factor. There was one between factor (group) with two levels (groups: Experimental and Conventional) and one within factor (time) with two levels (time: Pre and Post). All pair-wise post – hoc comparisons were analyzed using a 0.05 level of significance. Data was analyzed also using non parametric, Mann-Whitney U Test to test difference between pre to post change scores of conventional group with that of the experimental group. **Results**: The overall result of the study suggests that the experimental group (pelvic PNF; SEBT training & conventional exercises) and conventional group (conventional exercises) both had a significant improvement in step height, step length & stride length at the end of 4-weeks. However experimental group showed significantly more improvement in step length, stride length, step height of affected side, multidirectional step length in SEBT grid (anterolateral, anterior, anteromedial & medial) and in trunk control & balance measured by TIS & TBA. **Conclusion**: The study demonstrates that Conventional trunk exercises therapy combined with Pelvic PNF and SEBT grid stepping in multiple directions is superior to conventional trunk exercises alone in improving the gait parameters (step length and stride length), step height, step lengths in multi directions in SEBT grid, trunk control and functional balance in post stroke hemiplegic persons.

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Key Words: Balance, Stroke, Trunk Control,Proprioceptive Neuromuscular Fascilitation, SEBT

DOI: 10.18376/jesp/2021/v17/i2/167262

Introduction

According to WHO (Truelsen & Begg 2006) stroke is defined as “rapidly developing clinical signs of focal (or global) disturbance of cerebral function, with symptoms lasting 24 hours or longer or leading to death, with no apparent cause other than of vascular origin”. Stroke is also known as “cerebral vascular accident”, “brain attack” or “apoplexy”. The two major mechanisms causing brain damage in stroke are ischemia and hemorrhage. In ischemic stroke, which represents about 80% of all strokes, decreased or absent circulating blood deprives neurons of necessary substrates. The effects of ischemia are fairly rapid because the brain does not store glucose, the chief energy substrate and is incapable of anaerobic metabolism. Non-traumatic intra cerebral hemorrhage represents approximately 10% to 15% of all strokes. Intra cerebral hemorrhage originates from deep penetrating vessels and causes injury to brain tissue by disrupting connecting pathways and causing localized pressure injury (Javeed & Akram 2017). The cumulative incidence of stroke ranged from 105 to 152/100,000 persons per year, and the crude prevalence of stroke ranged from 44.29 to 559/100,000 persons in different parts of the country during the past decade. These values were higher than those of high-income countries (Kamalakannan et al., 2017). Of all possible sensorimotor consequences of stroke, impaired postural control in response to impaired trunk control probably has the greatest impact on ADL independence and gait (Kamphuis et al., 2013). However loss of trunk control & balance has been recognized (de Haart et al., 2004) as a major health problem in individuals with stroke resulting in a high incidence of falls both during rehabilitation and thereafter, particularly in those patients with both motor and sensory deficits. It is necessary to have optimal understanding of the potential mechanisms underlying ‘natural’ balance recovery and compensatory mechanisms to provide interventions to improve the speed and extent of balance and trunk control recovery following stroke. The site of the brain lesion will also affect the type and extent of postural reorganization after stroke (Geurts et al., 2005). Following the stroke limb function is also impaired along with impairment of trunk function. Trunk asymmetry appears bearing great percentage of body weight on an unaffected limb than on the affected limb. Concerning the range of motion (ROM) of the trunk in stroke patients, Mohr stated that “If there is not full range in all trunk movements (flexion, extension, lateral flexion and rotation), it will be more difficult to gain full control of the trunk. Any lack of ROM in trunk will lead to decreased function”. A study (Verheyden et al., 2006) showed an affiliation between trunk performance, balance, gait & functional ability after stroke. In addition, the trunk performance is also considered as a key prophet for the functional outcome after stroke (Khanal et al., 2013). Trunk seems to be bilaterally innervated and therefore assumed to cause less functional impairment as compared to the affected extremities (Gjelsvik et al., 2014).Dynamic stability of the trunk requires adequate flexibility, muscle strength, neural control, and proprioception. While deficits of trunk muscle strength have been identified in people post-stroke, it is not clear whether they have inadequate postural control and proprioception to ensure a stable foundation of balance to enable skilled extremity use. Trunk position sense is an essential element of trunk postural control. However, a specific impairment of trunk position sense has not been reported in people post-stroke (Ryerson et al., 2008). Contrary to common belief, the trunk muscles are impaired on both the sides of the body in patients with stroke. The weakness of trunk flexor-extensor and bilateral trunk rotator muscles leading to loss of trunk balance & control (Karthikbabu et al., 2011). A study (Karthikbabu et al., 2011) using Trunk Impairment Scale (TIS) also found that selective movements of the upper and the lower trunk are impaired in chronic stroke. In persons with hemiplegia, posture, tone and coordinate reciprocal movements that is control, which are required for normal gait, are usually impaired. Normal reciprocal pelvic movement is often replaced by a fixed pelvic retraction, which makes it difficult for patients to swing the affected lower extremity forward (Wang 1994). Pelvis is a part of trunk that supports extremity motions. Hence, the pelvic motion comes from trunk muscles. The range of motion in the pelvic patterns depends on the amount of motion in the lower spine (Khanal et al., 2013). Biomechanically it is impossible to move the pelvis without motion in the spine as it is connected with the spine. Specific pelvic patterns of Proprioceptive Neuromuscular Facilitation (PNF), which are mentioned in the literature not only exercise the pelvis motion and stability but also facilitate trunk motion and stability. In addition, these patterns help to improve functional trunk activities (trunk control) and treat the upper trunk indirectly through irradiation (Khanal et al., 2013). PNF helps in integration of motor control & learning; promotes higher level of function; involve active participation; application to all people & conditions. Techniques for facilitation of pelvic motion to improve control of the pelvis are primary choice. The pelvis has been described as a “key point of control” for maintaining gait pattern (Patni 2019). Although functional walking needs coordination between body parts and is modified, often in a subtle manner, to accommodate variation in task requirements and circumstances, such as walking speed, path curvature, and environmental clutter (Kumar et al., 2012).

Various authors have investigated the effects of pelvic PNF technique on gait pattern and have found improvement in cadence, stride length and gait duration; but there is hardly any study that has investigated its effectiveness in trunk movements that is essential for normal symmetry of body, balance and in functional activities. Hence, this study was aimed to find out the effects of pelvic PNF technique on facilitation of trunk movement/control in hemi paretic stroke patients (Khanal et al., 2013). Trunk performance using clinical measurement tool also found that significantly lower scores in people with stroke compared with age & gender-matched healthy individuals. Trunk performance remained impaired after stroke & also found to be strong relationship with measures of balance, gait & functional ability after stroke (Verheyden et al., 2006). The Star Excursion Balance Test (SEBT) which is a quantitative tool used in clinical and laboratory settings to assess dynamic balance. Originally described by Gray as a rehabilitative tool, the SEBT is a series of single-limb squats using the non stance limb to reach maximally to touch a point along 1 of 8 designated lines on the ground. The lines are arranged in a grid that extends from a centre point and are 45° from one another. Each reaching direction offers different challenges and requires combinations of sagittal, frontal, and transverse movements. The reaching directions are named in orientation to the stance limb as anterior, anteromedial, anterolateral, and medial, lateral, posterior, posteromedial, and posterolateral. The goal of the task is to have the individual establish a stable base of support on the stance limb in the middle of the testing grid and maintain it through a maximal reach excursion in 1 of the prescribed directions. While standing on a single limb, the participant reaches as far as possible with the reaching limb along each reaching line; lightly touches the line with the most distal portion of the reaching foot without shifting weight to or coming to rest on this foot of the reaching limb; and then returns the reaching limb to the beginning position in the centre of the grid, reassuming a bilateral stance. If the individual touches heavily or comes to rest at the touch-down point, has to make contact with the ground with the reaching foot to maintain balance, or lifts or shifts any part of the foot of the stance limb during the trial, the trial is not considered complete. These stipulations should be applied during rehabilitation. According to a study (Tokuno et al., 2011) the deeper abdominal muscles appear to be active similarly regardless of perturbation direction with the more superficial, demonstrating specific directional tuning of activity levels. Hence, movements of lower limb as described in SEBT grid protocol should help to improve the strength, endurance and coordination of muscles of the trunk.

Material and Method

A two group, pre-test post-test structured, experimental study design. The study was conducted at the Physiotherapy department of Swami Vivekanand National Institute of Rehabilitation Training and Research (SVNIRTAR). A total of 38 patients amongst the Sub acute and chronic hemi paretic stroke patients were recruited randomly. Group 1 (Experimental group) – 19 subjects, group 2 (Conventional group) – 19 subjects. Then informed consent was taken from the participants. All participants underwent an initial baseline assessment of Trunk Impairment Scale and Tinetti Balance Assessment. The subjects were asked to pick up one of the 38 paper chit and were randomly allotted into two groups.

Group – 1 (Experimental group) – 19 subjects with a mean age of 47.21±8.20 (yr) and mean duration of 0.68±0.42 (yr) performed SEBT training and Pelvic PNF for 20 minutes a day, along with conventional trunk exercises performed on plinth for 30 minutes a day, five times a week for four weeks duration. After completion of 4 weeks all participants received follow up assessment.

Group – 2 (Conventional group) – 19 subjects with a mean age of 52.47 ±7.96 (yr) and mean duration of 0.78±0.38 (yr) performed conventional trunk exercises on plinth for 30 minutes a day, five times a week, for four weeks duration.

Inclusion criteria: Sub-acute & chronic unilateral hemi paretic stroke patients; age group between 40 to 60 yrs; both male & female; duration of 3 to 12 months; ambulatory patients only with or without walking aids; scoring less than or equal to 21 out of 23 on Trunk Impairment Scale; without any fixed hip, knee and ankle deformity; could able to stand independently for 90 seconds on a stable surface.

Exclusion criteria: No previous treatment of pelvic PNF & SEBT grid since 6 weeks; patients with ACA & PCA territory involvement; having aphasia; medically unstable; uncontrolled hypertension; spinal deformity; pelvis # less than 6 months; impaired cognitive functions; any neurological disease affecting balance other than stroke such as Cerebellar disorders, Parkinson's disease and/or Vestibular lesion; musculoskeletal disorders such as low backache, arthritis or degenerative diseases of the lower limbs affecting motor performance.

Outcome measures

Trunk Impairment Scale (TIA): A new tool to measure motor impairment of the trunk after stroke. The total score ranges from minimum 0 to maximum 23 points, a higher score indicating a better performance. It measure static and dynamic sitting balance as well as trunk co-ordination. It also aims to score the quality of trunk movement and to be a guide for treatment. The total TIS score above 21 is considered to be the normal trunk performance in sub-acute and chronic stroke persons.

Tinetti Balance Assessment (TBA): To document gait parameters and balance. TBA consists of a hierarchical series of functional performance tests that range from supported sitting balance to advanced stepping tasks. There are three sections to the assessment: sitting, standing and stepping.

Conventional group exercises

Sitting exercises- Weight shift forward and backward, Leaning down on elbow, Lateral reaching, Forward reaching, Trunk rotation

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Transition phase exercise- Sit to stand and sit down
Standing exercises- Step up and step down, Standing balance
Perturbation
Experimental group exercises
Side lying exercises:
Pelvic PNF pattern; anterior elevation and posterior depression.
The treatment in this study consisted of 7 minutes each of rhythmic initiation, slow reversal, and agonistic reversals applied to the pelvic region. These procedures were done to facilitate anterior elevation and posterior depression of pelvic movement in a side-lying position. 5 each treatment session lasted 20 minutes, with a total of 20 treatment sessions (five times a week for 4 weeks).
Standing exercises:
SEBT grid exercises in multiple (4) directions; anterolateral, anterior, anteromedial and medial.
Step up and step down.
Exercises were gradually introduced and the number of repetitions was determined by the therapist on the basis of patient's performance. The intensities of the exercises were increased by introducing one or several of the following changes:

- Reducing the base of support.
- Increasing the lever arm.
- Advancing the balance limits.
- Increasing the hold time.
- Increasing the number of repetitions on the basis of patient's performance.

Conventional exercises include tone facilitation; stretching and range of movement; exercises for hemiplegic side.
Measurements were taken prior to the beginning of treatment and were repeated finally after the completion of 4 weeks of treatment protocol.
Data collected were transcribed onto a data sheet for each subject separately. Analysis was performed using SPSS versions 16.0 package. The dependent variables were analyzed using a 2X2 ANOVA, repeated measures on second factor. There was one between factor (group) with two levels (groups: Experimental and Conventional) and one within factor (time) with two levels (time: Pre and Post). All pair wise post – hoc comparisons were analyzed using a 0.05 level of significance. Data was analyzed also using non parametric, Mann- Whitney U Test to test difference between pre to post change scores of conventional group with that of the experimental group.

Result and Discussion

There was no main effect for group (f=0.297, df=1, p=o.589). However there was a main effect for time (f=118.650, df=1, p=0.000). The main effect also qualified to interaction of time x group (f=14.856, df=1, p=0.000).
Post hoc analysis revealed statistically significant improvement from pre to post score of step height in both group (experimental & conventional) after 4 weeks. But extent of improvement in experimental group was more as compared to conventional group.

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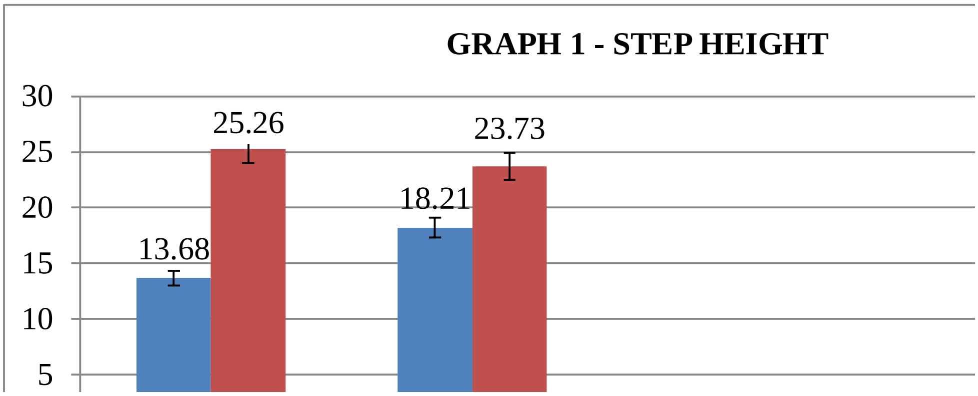
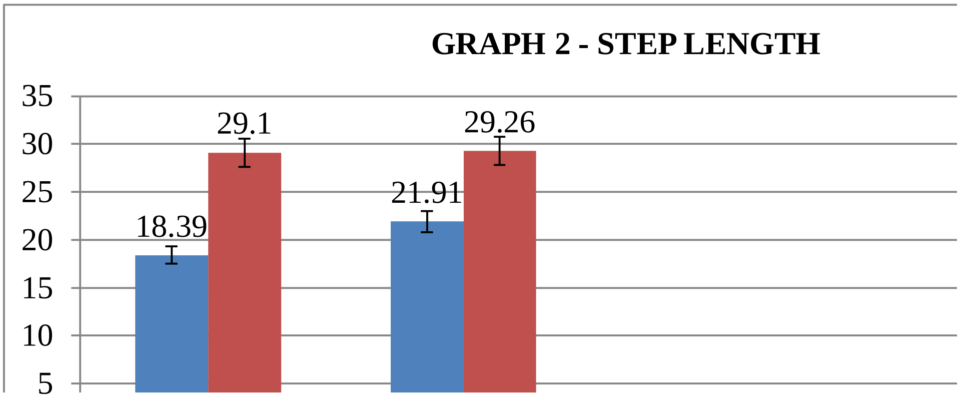
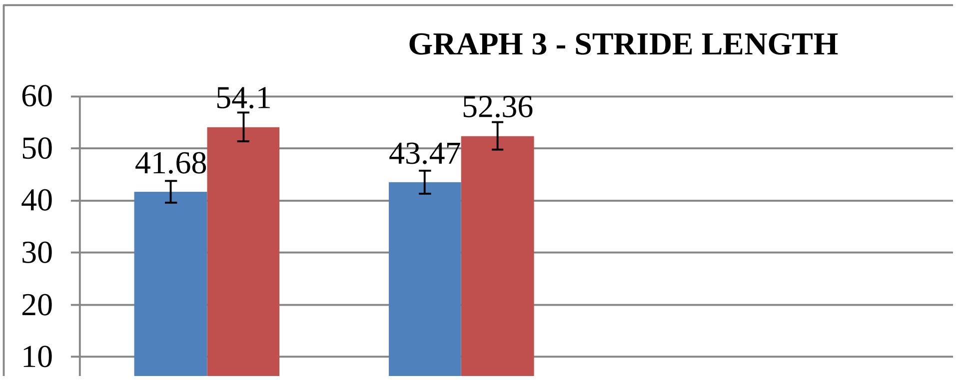


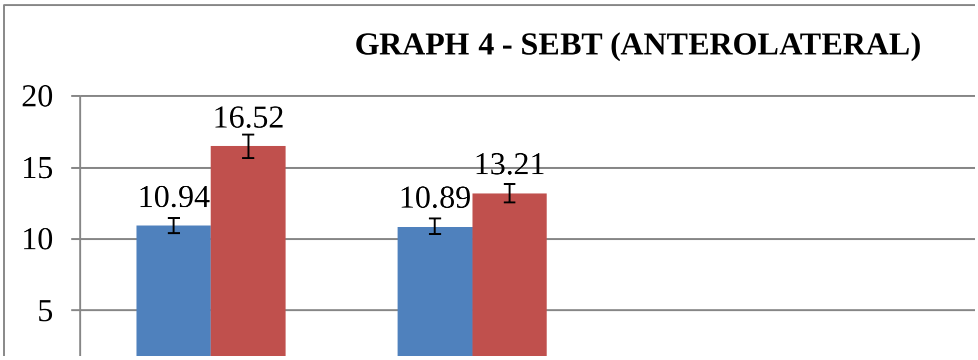


There was no main effect for group (f=0.416, df=1, p=o.523). However there was a main effect for time (f=121.679, df=1, p=0.000). The main effect also qualified to interaction of time x group (f=4.221, df=1, p=0.047).

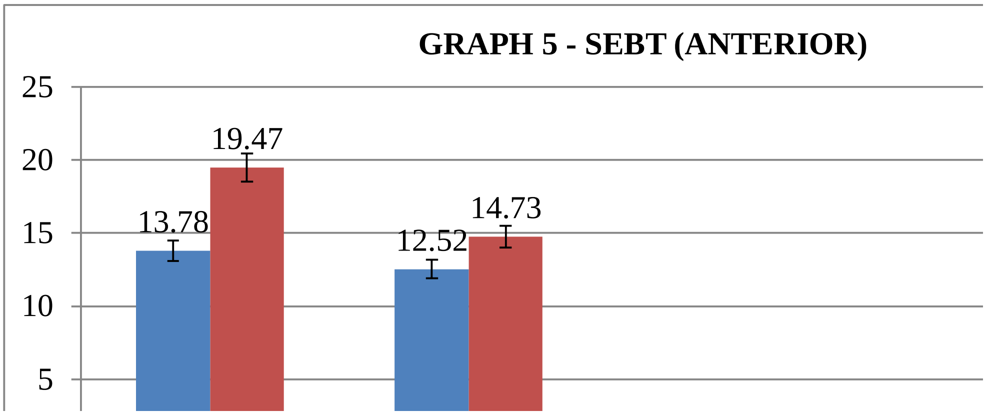
Post hoc analysis revealed statistically significant improvement from pre to post score of step length in both group (experimental & conventional) after 4 weeks. But extent of improvement in experimental group was more as compared to conventional group.



The main effect not qualified to interaction of time x group (f=2.687, df=1, p=0.110). There was no main effect also for group (f=0.000, df=1, p=o.997). But there was a main effect for time (f=98.199, df=1, p=0.000).
Post hoc analysis revealed statistically significant improvement from pre to post score of stride length in both group (experimental & conventional) after 4 weeks. But extent of improvement in experimental group was more as compared to conventional group.



There was no main effect for group (f=2.368, df=1, p=o.133). But there was a main effect for time (f=245.752, df=1, p=0.000). The main effect also qualified to interaction of time x group (f=41.985, df=1, p=0.000).
Post hoc analysis revealed statistically significant improvement from pre to post score of SEBT (anterolateral) in both group (experimental & conventional) after 4 weeks. But extent of improvement in experimental group was more as compared to conventional group.



There was a main effect for time (f=175.781, df=1, p=0.000). The main effect also qualified to interaction of time x group (f=34.031, df=1, p=0.000). At the same time there was a main effect also for group (f=6.827, df=1, p=o.013).

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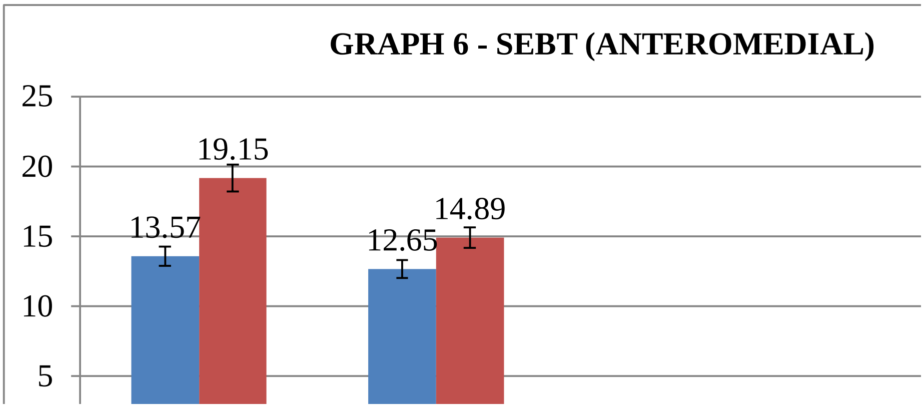
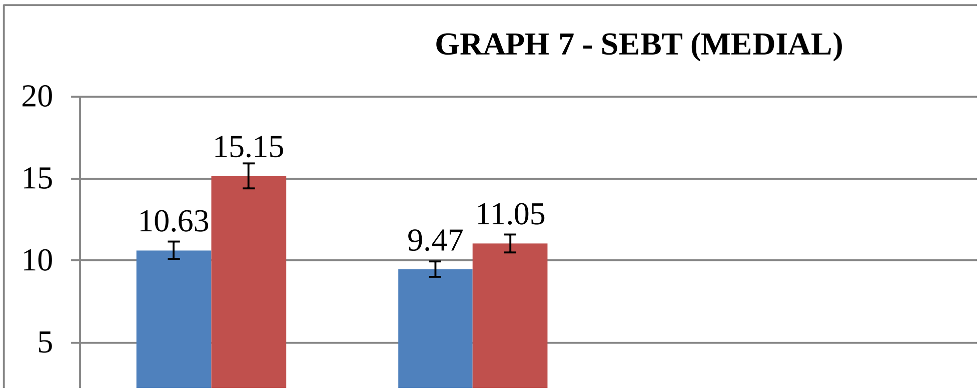
Post hoc analysis revealed statistically significant improvement from pre to post score of SEBT (anterior) in both group (experimental & conventional) after 4 weeks. But extent of improvement in experimental group was more as compared to conventional group.



There was a main effect for time (f=171.502, df=1, p=0.000). The main effect also qualified to interaction of time x group (f=31.359, df=1, p=0.000).At the same time there was a main effect also for group (f=4.151, df=1, p=o.049).

Post hoc analysis revealed statistically significant improvement from pre to post score of SEBT (anteromedial) in both group (experimental & conventional) after 4 weeks. But extent of improvement in experimental group was more as compared to conventional group.



There was a main effect for time (f=130.923, df=1, p=0.000). The main effect also qualified to interaction of time x group (f=30.512, df=1, p=0.000). At the same time there was a main effect also for group (f=5.721, df=1, p=o.022).

Post hoc analysis revealed statistically significant improvement from pre to post score of SEBT (medial) in both group (experimental & conventional) after 4 weeks. But extent of improvement in experimental group was more as compared to conventional group.

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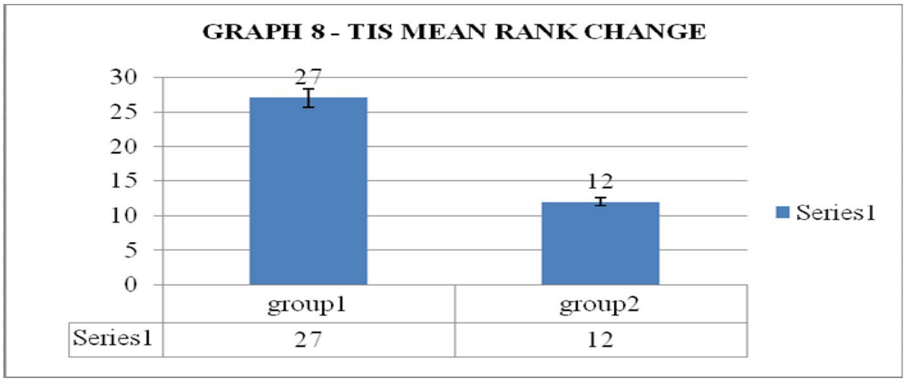
Graph 1 – 7 illustrate that there was improvement in step height, step length, stride length, SEBT grid (anterolateral, anterior, anteromedial & medial) respectively in both the groups from pre - treatment to post – treatment but the experimental group showed greater improvement as compared to the conventional group at the end of 4 weeks of treatment session.



Mann-Whitney U test showed that there is a statistically significant difference in the change score of TIS between the groups. (P=o.oo, Z=-4.240). So the extent of improvement in experimental group is more.

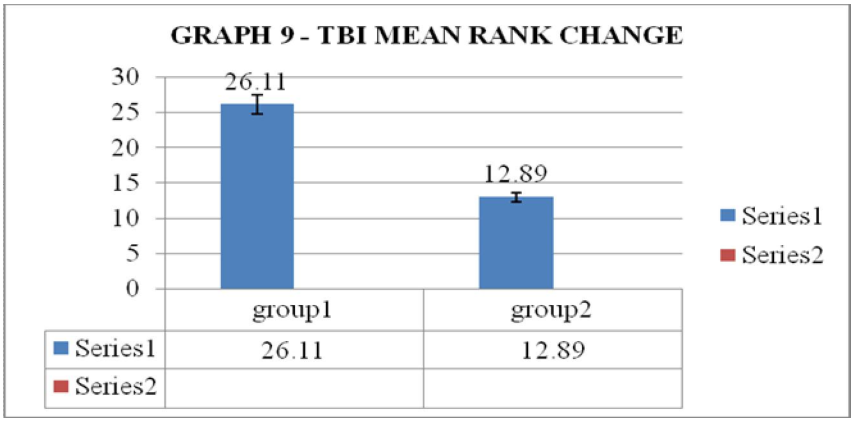


Figure 9. TBI Mean Rank Change

Mann-Whitney U test showed that there is a statistically significant difference in the change score of TINETI between the groups. P=o.oo, Z=-3.682). So the extent of improvement in experimental group is more.

The overall result of the study suggests that the experimental group (pelvic PNF; SEBT training & conventional exercises) and conventional group (conventional exercises) both had a significant improvement in step height, step length & stride length at the end of 4 weeks. However experimental group showed significantly more improvement in step length, stride length, step height of affected side, multidirectional step length in SEBT grid (anterolateral, anterior, anteromedial & medial) and in trunk control & balance measured by TIS & TBA.

Step height:

Results of study showed that post-intervention, both the groups significantly improved in step height but the experimental group improved significantly more than that of conventional group. The improvement in the conventional group could be due to the effect of forward & lateral step up exercises, which was given in the form of conventional physiotherapy to the conventional group. Step up initiated with a limb lift via vigorous contraction of the iliopsoas, which pulls the limb up against gravity to the step. The rectus femoris becomes active in this phase as it assists in the thigh flexion and eccentrically slows the knee flexion. Next, the foot is placed on the step. At this point, there is activity in the hamstrings, primarily working to slow down the extension at the knee joint. As the foot makes contact with the step, weight acceptance involves some activity in the extensors of the thigh (Abbass 2012) in contrast to step up during step down, all muscles works in reverse direction (concentric to eccentric & vice versa).

Lateral step up places greater demand on the knee extensors and ankle planter flexors, forward step-up places greater demand on the hip extensors (Vats 2013). Placing the foot on a high step may be an appropriate strategy to improve gait parameters i.e. step length & stride length. It may be largely due to the learning and practice effects associated with the conventional interventions. However, the step up exercise intervention additionally reinforced balance, strength and loading of the affected as well as unaffected limb. It is an established fact that Step-up exercise is a means of weight bearing exercises to increase lower limb muscle neuromuscular coordination (Vats 2013). Moreover, lateral step up exercises were found to improve the loading response by influencing the shifting of COG through the enforced recruitment of gluteus medius activity of the supporting leg and adductor longus of stepping leg (Vats 2013). And this had taken over to improve functional balance. Finally over all effects had reflected in terms of improved trunk control.

Experimental group showed significantly more step height on affected side which might be due to the conventional exercise program along with Pelvic PNF in terms of anterior elevation (Flex-Add-Ext Rotation), and posterior depression (Ext-Abd-Int Rotation) technique. (Through the process of rhythmic initiation, slow reversal and agonistic reversal).

Anterior elevation of pelvis caused to made recruitment of lower abdominals and hip flexors and irradiation to upper trunk flexors of involve side. This was important for initiation and progression of swing phase in gait cycle. And posterior depressions of pelvis caused to have trunk lengthening as well as extension of lower extremity of involve side. This was an important pattern for stance phases (toe-off/push-off) in gait cycle. Thus Pelvic PNF did major improvements immediately post treatment in stance stability and limb advancement in the involved limb. The changes in knee motion had occurred secondary to improvements in pelvic and hip motion. Thus higher step height achieved. The physiological mechanism for increasing the ROM of Pelvis, hip, knee & ankle through the step up exercises might be due to autogenic inhibition, reciprocal inhibition, and stress relaxation. The experimental group practiced steps on multi directions in SEBT grid, participants had practiced repetitively in all 4 directions (AL, ANT, AM, M directions). This might be reason to improve in step height, as during training in SEBT grid while swing lower limb reached to a maximum. There are evidences of recruitment of the abdominals (rectus and obliques), hip flexors and developed the eccentric control of Gluteus maximus, hamstring as well as ankle dorsiflexor in this manoeuvre. Also reduction in increased tone and improvement of ROM, strength of swing lower limb resulted in improved pelvis and lower limb control through lumbopelvic dissociation and pelvic-hip coordination. This had helped in improvement of step height.

Step length & Stride length and Multidirectional Step length by SEBT grid:

Results of study showed that both the group improved significantly in step length & stride length and multidirectional step length by SEBT grid, however experimental group improved more.

- Improvement in the conventional group could be due to the effect of truncal exercises comprised of In 90/90 sitting – Weight shift forward and backward, leaning down on elbow, lateral reaching, forward reaching, trunk rotation exercises.
- In standing – step up and down exercises, sit to stand (transition), standing balance, and perturbation in standing, which was given in the form of conventional physiotherapy to the conventional group.

As in sitting exercises, had caused to made increased pelvic mobility through pelvic shift forward and backward, concentric loading of same side trunk lateral flexors and eccentric loading of opposite side trunk lateral flexors during leaning on elbow activity, co contraction of abdominals and erector spinae group of muscles during lateral reaching to increase stability, enhancement of internal obliques of same side and external obliques of opposite side in the course of upper and lower trunk rotation.

Also in standing exercises, had caused to made increased strength of hip, knee and ankle flexors/extensors due to practice of step up and down exercises as well as sit to stand pattern, standing balance exercises had added core stability, and standing perturbation had improved proactive as well as reactive reactions, at the same time anticipatory postural control or feed forward control. During all of these exercises, there were recruitment of abdominals, erector spinae group of muscles, quadratus lumborum and upper extremity (deltoid) as well as lower extremity (hip, knee, ankle flexors/extensors muscles), because of that improved strength, ROM (trunk, pelvis, hip, knee and ankle mobility) and further development of anticipatory postural adjustment (voluntary control), trunk stability, coordination of trunk, pelvis and lower limb, this had been reflected in improved step length and stride length. Following study favour the same results. The central nervous system (CNS) counteracts the expected mechanical effects of the perturbation induced by movement in a feed forward manner through anticipatory postural adjustments (APAs), which are changes in the background muscle activity (Shiratori & Aruin 2004). And trunk displacement was greater in post-stroke subjects as recorded in EMG analysis done in a study actuated by (van der et al., 1998).The sit-to-stand movement pattern can be divided into two phases. The first phase, the flexion phase, occurred during the first 35% of the movement cycle. The second phase, the extension phase, then began at the head and knee. Rajrupinder kaur rai stated that trunk exercises were effective at enhancing trunk control and balance but gait (step and stride length) also improved significantly (Rai et al., 2014). A study (Karthikbabu et al., 2011) supports present study. He studied the role of trunk rehabilitation on trunk control, balance and gait in patients with chronic stroke. The study indicated the importance of trunk exercises in the rehabilitation of stroke patients. Improvements in balance and gait (step and stride length) occurred because both the trunk rehabilitation program and balance training consist of the use of lower limb muscles which account in change of balance and gait. Gait improved just not because of selective flexion and extension movements but also because of rotation exercises of upper and lower trunk. Gait (step and stride length) and balance also improved because the motor control proceeds from proximal to distal, the improved level of proximal trunk control leads to improvement in distal lower limb control which helped in attaining better balance and gait (step and stride length) (Karthikbabu et al., 2011). Experimental group improved more this could be due to additional exercises (SEBT grid and Pelvic PNF) given to experimental group. Major problems in stroke patients seen in terms of reduced or absent pelvic movement and minimal or absent lower trunk activity, disturb pelvic-hip rhythm and lumbopelvic association, absent or minimal lower limb control along with increased lower limb tone as a result abnormal synergy pattern. So reduced step length and stride length while walking, although affected side step and stride length was more than unaffected side. Decreased stance time on affected side in order that impaired strength, coordination and balance also had been noted. During SEBT grid performance, affected lower limb had moved forward in multi-directions (AL, ANT, AM, M), while standing on normal lower limb. Participants touched the target point up to maximum again and again (6 times) without losing the balance, this repeated practice might be cause to have an increase in pelvic forward rotation and development of controlled hip flexion, controlled knee extension and ankle plantar flexion. Increased in, both the ROM and strength of hip flexion, knee flexion and ankle dosiflexion as well as increased abdominal muscle strength with the result that improvement in trunk flexion and rotation. There was evidence that task specific activities had made an increase in neuromuscular control of trunk and lower limb (swing), and increased Gluteus maximus control and abductor strength, some short of push-off as well. Increased awareness of lower limb position sense had noted as well. All these factors might be responsible for improved step length and stride length in terms of improved gait. A study on electromyography analysis found an impaired anticipatory postural trunk muscles activity in patients with stroke, which in turn essential for static postural control. Furthermore, studies on posturographic analysis found an impaired dynamic postural control in patients with stroke. Star Excursion Balance Test (SEBT), a test of dynamic postural control maintaining a stable base of support while completing a prescribed movement (Gribble & Hertel 2003). So it might be helped in this study to be improved gait parameters that are step length and stride length. Another explanation to Improvement in experimental group as could be due to fact that pelvic PNF had also contributed which cause to made improvement in pelvic motion, hip motion, and hip-pelvic coordination. Strengthening of abdominals and hip flexors as well as indirectly had affected the knee flexors and ankle dorsiflexor by the way of pelvic anterior elevation and posterior depression. Thus development of trunk, pelvis and lower extremity (affected) control as a whole in terms of reducing tone and improving gait parameters, through selective trunk, pelvis and hip muscles exercise training primarily and knee flexors and ankle dorsiflexors secondarily. Due to all of these factors Pelvic PNF had improved trunk, pelvis and lower limb (affected) neuromuscular control (static and dynamic) which might be reflected in the form of improved functional balance and trunk control as carried-over effects. Thus pelvic PNF ultimately had improved gait parameters (step length and stride length). Motor learning literature suggests that training needs to be specific to the task that the person needs to do. A study by S. Kartikbabu on involving the analysis of trunk kinematics during walking found that pelvic movements were unstable and asymmetrical in patients with stroke. Consequently, there may be a possibility exists that selective trunk muscle exercise training may enhance symmetrical pelvic movements, thus better weight shifting towards hemiplegic limb during walking (Karthikbabu et al., 2011). A study by Trueblood et al. favours this hypothesis. In their study, PNF based resisted anterior elevation and posterior depression of pelvic movements for trunk muscles had resulted better temporal gait symmetry in patients with sub-acute stroke (Trueblood et al. 1989). Motor control literature also suggest that if an improved level of proximal trunk gains were attained, a better distal limb control might be expected during balance and functional mobility. In addition, the improvement seen in this study group could be due to natural recovery too. A study by Verheyden et al. found a positive association between the trunk performance, balance and gait after stroke. The improvement in trunk performance in this study might further aid in improving the balance and gait (Verheyden et al., 2006). More improvement in experimental group for functional balance might be attributed to multidirectional additional pelvic PNF plus SEBT grid stepping. Because this had actuated enhancement in pelvic motion, dissociation between trunk and pelvis and association between hip and pelvis along with projected strength and range of motion of these. Also contributed to recruitment of hip flexor, knee flexor and ankle plantar flexor while in pre swing phase followed by recruitment of hip flexor, knee flexor and ankle dorsiflexor during initial and mid swing and finally controlled hip flexion, knee extension and ankle plantar flexion while directed towards terminal swing. Thus did improved trunk, pelvis and lower limb control and coordination, reflected in terms of better trunk performance, improved gait and functional balance.

Trunk Impairment Scale (TIS): The improvement (change in post minus pre) in TIS was more in experimental group. Improvement in the conventional group could be due to the effect of truncal exercises including Weight shift forward and backward, leaning down on elbow, lateral reaching, forward reaching, and trunk rotation exercises in 90/90 sitting; which was given in the form of conventional physiotherapy to the conventional group, aimed to improve trunk performance. Truncal exercises had actuated the dissociation between upper trunk and lower trunk as a major concern and had enhanced pelvic motion, higher level of strengths of trunk primarily and secondarily of lower extremity up to some extent, tended to normalize the tone of trunk as a whole and affected lower extremity. These exercises also had developed the feed forward control or voluntary control along with rhythm and coordination. Thus ultimately had exceeded the trunk performance and led to better trunk control. Task specific training in terms of truncal exercises had led to plasticity of the sensorimotor regions of the central nervous system (Khanal et al., 2013). Karni et al. using functional MRI, and Classen et al. using Trans cranial Magnetic Stimulation, both reported a slowly evolving, long-term, experience-dependent reorganization of the adult primary motor cortex after daily practice of task-control group when evaluated by Trunk Impairment Scale (Karni et al., 1995; Classen et al., 1995). This could be due to the effect of truncal exercises in terms of conventional exercises. Additional pelvic PNF plus SEBT grid stepping in multidirectional which might improved the trunk control because of recruitment of abdominal muscles as well as hip, knee, ankle flexors/extensors and also added trunk, pelvic and hip mobility as well as dynamic control along with better coordination.

Tinetti Balance Assessment (TBA): The improvement (change in post minus pre) in TBA was more in experimental group. The measures of the tinetti balance and therapy given in this study were to some extent similar. Standing (balance and perturbation) and lifting limbs as well as sit to stand resulted in anticipatory postural control, which were even part of independent variables. In the experimental group improved balance as a result of normalized tone up to some extent, improved ROM of trunk, pelvis and lower limb, , higher level of pelvic stability as well as increased steps and stride lengths led to better trunk control and performance. End results were that changes in tinetti measures might be owing to additional therapy by Pelvic PNF and SEBT grid.

Conclusion

The study demonstrates that Conventional trunk exercises therapy combined with Pelvic PNF and SEBT grid stepping in multiple directions is superior to conventional trunk exercises alone in improving the gait parameters (step length and stride length), step height, step lengths in multi directions in SEBT grid, trunk control and functional balance in post stroke hemiplegic persons.

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Conflict of Interest: None declared