Additional Effect of Trunk Stabilization Exercises on Gait and Balance in Chronic Stroke Patients: An Experimental Study

Bansari J. Gadhvi, Shraddha J. Diwan, Neeta J. Vyas

Abstract

Background: The trunk being the central key point of the body; proximal stability of the trunk is pre-requisite for distal limb mobility, balance, gait and functional activities which is affected because of impaired trunk muscle strength and motor control. Purpose: To determine whether additional Trunk Stabilization Exercises along with conventional therapy program will improve gait and balance in chronic stroke patients. Methods: n=22 subjects with chronic stroke were recruited by convenient sampling method and divided in either Experimental group (n=12) and in Control group (n=10). Trunk control, gait and balance were tested by TIS, 10 MWT, BBS, step length, stride length and cadence. Subjects received 30 minutes of additional trunk stability exercise program 3 times/week for 4 weeks. Results: Results were analysed by SPSS version with level of significance kept at 5%. There was significant improvement in TIS, BBS, 10 MWT and cadence in both the groups with significant improvement of step length and stride length on non-affected limb in comparison to non-significant difference in affected limb. Conclusion: Additional Trunk Stabilization Exercises should be considered not only to improve trunk control but also to improve gait and balance as well.

Key words: Trunk stabilization, stroke, TIS, gait, balance, BBS, 10MWT

Introduction

According to WHO, stroke is defined as rapidly developing clinical signs of focal (or global) disturbance of cerebral function lasting more than 24 hours or leading to death with no apparent cause other than that of vascular origin. Trunk control is the ability of the trunk muscles to allow the body, to remain upright, adjust weight shift, and perform selective movements of the trunk so as to maintain the center of mass within the base of support during static and dynamic postural adjustments. Trunk control and stability involve complex pyramidal and extra-pyramidal systems that are frequently disturbed in stroke. Hemiplegic patients, show a decrease in thickness of muscle fibers and the rate of motor unit firing as well as shrinkage of muscle fibers that result in weakness of the muscle, which affects the stability of trunk, co-ordination of movement and balance. Trunk muscle strength measured by means of hand held dynamometer has shown to be significantly impaired in people with stroke in comparison to matched controls for lateral flexion to affected and non-affected side as well as forward flexion. Dean and colleagues reported on the beneficial effect of practicing reaching tasks beyond arm’s length on sitting ability and quality, reaching and standing up, both in acute and chronic phase after stroke. After six months of training, participants in experimental group showed significantly larger reach distance and peak vertical force through the affected foot during standing when treated early after stroke. Verheyden et al, showed significant improvement in sitting balance measured by TIS and selective trunk movements on performance of lateral flexion following additional trunk exercises done for 5 weeks. Unlike hemiplegic limb muscles, the trunk muscles are impaired on both sides of the body following a unilateral stroke as evaluated by computed tomography and motor evoked potential studies. During steady-state walking the HAT segment’s primary task is to control balance. The trunk and hip muscles play an important role in this respect. As a result of asymmetric gait pattern the various gait parameters like walking velocity, stride length, cadence, support time on the involved limb, weight transfer through the limb are decreased thereby increasing the energy cost of gait. Researches have trunk mobility to be included in the study of gait asymmetry among stroke patients.

Need:

Restoration of independent gait and balance is a main aim of rehabilitation for patients living with stroke, because it is associated with independent mobility and reduced fall risk. Altered trunk control leads to postural instability which delays the recovery of gait and functional independence. Most therapy approaches for chronic stroke patients focus more on gait, balance and limb functions without addressing trunk stability. Hence rationale of the present study is to check additional effect
of trunk stability on gait and balance in chronic stroke patients.

Methods: Ethics approval was taken by the Institutional Review Board. Informed written consent was taken from the patients and relatives. Chronic hemiplegics with first onset aged between 30-60 years who were able to follow and understand simple instructions MMSE>24, able to sit independently for 30 seconds and able to walk 10-meter distance, were included for the study. Subjects with sensory, perceptual and cognitive disorders, medically unstable patients, multiple strokes, other musculoskeletal disorders affecting motor performance were excluded. N=28 patients were eligible for inclusion and assigned out of which n=22 completed the study over a period of 1 year. Design: Subjects in both the groups received regular 45 minutes of conventional therapy which included stretching, strengthening exercises, balance training and gait training. Subjects in Experimental group A (n=12) received 30 minutes of additional trunk stabilization exercises, 3 days a week for 4 weeks, along with a daily conventional therapy program. Supine exercises included unilateral pelvic bridging, trunk flexion and rotation in crook lying, upper and lower trunk rotation. Exercises in sitting included, multi-directional reach-outs to promote forward flexion, rotation, lateral flexion and extension- rotation in sitting, selective upper and lower trunk rotation with adequate rest in between. Progression of exercises were done by decreasing need of assistance, increasing number of repetitions based on patient's performance.15,16 These exercises were administered with adequate rest periods in between. The intensity of exercise was increased by introducing one or several of the following changes: 17 (1) Reducing the base of support (2) Increasing the lever arm (3) Advancing the balance limits (4) Increasing the hold time. Subjects in Control group B (n=10), received regular conventional therapy with 3 times/week for 4 weeks of additional 30 minutes of other exercises such as 10 minutes fine-motor, 10 minutes facial muscle exercises and 10 minutes co-ordination exercise in sitting with semi-reclined position trunk support in a chair with arm-rest and pillows for support to prevent trunk movement. Caution was taken that no trunk movement should get challenged. Post-treatment outcome measures were taken after 4 weeks.

Statistical Analysis: As the data was not normally distributed, non-parametric tests were applied. Between group analysis was done by Mann Whitney– U test, within group analysis was done by Wilcoxon signed rank test.

The pre-treatment and post-treatment results were entered as within-subjects variable “time”, the experimental and control groups were included as between-subjects factor “condition”. P values for the variable “time” would indicate whether there is significant change between pretreatment and post-treatment assessment. A significant interaction of “time*condition” would mean that the change between pretreatment and post-treatment evaluation is significantly different between the experimental and control groups. Data analysis was performed using SPSS for Windows version 16.0 with level of significance 5 % and confidence interval (CI) 95%.

Results:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Experimental Group</th>
<th>Control Group</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (mean [SD] years)</td>
<td>58.83 (2.358)</td>
<td>57.60 (3.187)</td>
<td>1.00</td>
</tr>
<tr>
<td>Gender (male/female)</td>
<td>7/5</td>
<td>5/5</td>
<td>0.70</td>
</tr>
<tr>
<td>Time since stroke onset (mean [SD] score)</td>
<td>10.17</td>
<td>13.10</td>
<td>0.288</td>
</tr>
<tr>
<td>Side affected (right vs. left)</td>
<td>8 vs. 4</td>
<td>6 vs. 4</td>
<td>0.75</td>
</tr>
<tr>
<td>TIS</td>
<td>12.88</td>
<td>9.85</td>
<td>0.27</td>
</tr>
</tbody>
</table>

Characteristics of both groups are shown in Table 1. shows no significant differences between subjects in experimental and control groups for baseline demographic variables like, age, gender, post-stroke duration, side affected and baseline trunk control. Results of the general linear repeated measures model are presented in Table 2. All P values of the variable “time” were significant, except step length and stride length of paretic limb side (p=0.083 for group A) (p=0.081 for group B). The interaction parameter of “time*condition” improved significantly better for the score of TIS (p=0.010), for BBS (p=0.030) and for 10-meter walk test, speed (p=0.00), for cadence (p=0.007), step-length non-paretic (0.003), stride length non-paretic limb side (p=0.001), it was only non-significant for step length and stride length of paretic limb side.

Discussion:

Present study was aimed to evaluate the additional effect of trunk stabilization exercises on gait and balance in chronic stroke patients. Results of present study suggests that additional trunk stabilization exercises with selective trunk movements improves trunk control, balance and gait speed measured by 10 MWT, cadence, step length and stride length of non-paretic side of limb. Trunk performance is related to measures of balance, gait and functional ability in patients with stroke.18 It has also been identified as an important early predictor of functional outcome after stroke.19,20,21
<table>
<thead>
<tr>
<th>Outcome Measure</th>
<th>Group A</th>
<th>Group B</th>
<th>U value</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>+ SD</td>
<td>Mean</td>
<td>+ SD</td>
</tr>
<tr>
<td>TIS</td>
<td>4.33</td>
<td>1.435</td>
<td>2.70</td>
<td>1.703</td>
</tr>
<tr>
<td>BBS</td>
<td>7.83</td>
<td>3.664</td>
<td>4.40</td>
<td>2.797</td>
</tr>
<tr>
<td>Speed</td>
<td>0.7082</td>
<td>0.4135</td>
<td>0.0580</td>
<td>0.06442</td>
</tr>
<tr>
<td>Cadence</td>
<td>12.50</td>
<td>7.230</td>
<td>5.90</td>
<td>4.624</td>
</tr>
<tr>
<td>Step Length NA</td>
<td>6.54</td>
<td>3.751</td>
<td>2.60</td>
<td>2.747</td>
</tr>
<tr>
<td>Step Length Aff.</td>
<td>22.750</td>
<td>16.8381</td>
<td>24.550</td>
<td>9.4882</td>
</tr>
<tr>
<td>Stride Length NA</td>
<td>13.08</td>
<td>7.501</td>
<td>4.60</td>
<td>3.748</td>
</tr>
<tr>
<td>Stride Length Aff.</td>
<td>4.93</td>
<td>3.066</td>
<td>5.80</td>
<td>4.264</td>
</tr>
</tbody>
</table>
The trunk has a control function during gait, it plays an important role in navigation, minimizes the vertical displacement of the upper body, and weakens the time related fluctuations in head movements. The kinematics of the trunk can be complementary to the kinematics of the legs, such as when the trunk is oriented secondary to foot position or vice versa.

The anticipatory postural adjustment of trunk muscles activity is impaired in patients with stroke. Trunk stabilization exercise increases the Deep Abdominal Muscle Thickness and functional Balance in chronic stroke patients. There is significant improvement in both the groups in within group analysis in TIS and BBS scores with experimental group with better improvement (p=0.010) and (p=0.030) respectively. Also, the study showed 50% of subjects of experimental group with surpassing BBS scores (> 45) post-treatment, thereby decreasing the fall risk, as compared to control group in which 40% of subjects showed BBS scores beyond 45. Step length and stride length on non-paretic limb side also showed a significant difference in within group analysis and between group analysis in which experimental group showed significantly better improvement with p=0.003 for step length and p=0.001 for stride length. Possible explanation for the same may be that, selective trunk muscle exercise training may enhance symmetrical pelvic movements, thus better weight shifting towards hemiplegic limb during walking. With trunk rehabilitation, there may be increased single limb support time on affected limb which may be reason for the improvement in gait symmetry and for the increase in step length and stride length of the non-affected side as the patient will be able to shift weight on the affected side limb. S. Karthikbanu et al., has also found improvement in spatial gait parameters compared to temporal gait parameters with the exception of affected single limb support time.

Results of present study didn’t show any statistically significant improvement in step length and stride length of paretic side in within group or between group analyses. For possible improvement in step length of affected side, factors such as dorsiflexors recruitment, adequate hip-knee flexion in swing phase, single limb stance duration and lower limb synergy as well as gait pattern like circumductive gait should be taken into consideration.

Jessica L. Allen, studied the kinematics of gait on 55 hemiparetic patients walking at their self selected speed and stated that Step Length asymmetry as a representative of compensatory mechanisms used in Post-Stroke hemiparetic walking, results of their study suggest that the direction of asymmetry can be used to identify both the degree of paretic plantar flexor impairment and the compensatory mechanisms used by post-stroke hemiparetic subjects. The spatiotemporal characteristics of gait describe the quantitative aspects of the movement pattern. According to Leung and Moseley, changes in step length, duration in the stance and swing phases, and double support time are related to reductions in gait symmetry and gait velocity, leading to the specific gait pattern exhibited by patients with hemiparesis that is a relatively shorter step length, a longer stance phase and a shorter swing phase of the affected side. But strength of lower limb muscles was not considered in present study. There was a significant difference found in within group analysis of cadence and speed but between group analyses states that experimental group showed significantly better results in cadence and speed than the control group. Recent studies on posturographic analysis observed that stroke patients tend to avoid shifting their center of pressure towards the hemiplegic side in sitting and standing. A study involving the analysis of trunk kinematics during walking found that pelvic movements were unstable and asymmetrical in patients with stroke.

Goldie et al. reported that the two determinants of gait speed, cadence and step length, decrease after stroke. A change in cadence i.e. 5 steps increase, may be the potential contributing factor for increased speed in their study participants. In addition, the significant change was seen in all the spatial parameters may further support for the improved gait speed. Furthermore, the probable reason for change in gait speed may be due to improved trunk control and dynamic balance with trunk rehabilitation. Therefore, if an improved level of proximal trunk control is attained, better distal lower extremity mobility might be anticipated such as that involved in walking.

The study findings are of clinical importance since they indicate an improved trunk control, balance and gait owing to an inclusion of selective trunk muscle exercise regime in the rehabilitation of patients with chronic stroke.

Conclusion:
This study concluded that though conventional exercises improves balance and gait speed, additional Trunk Stabilization Exercises are more effective in comparison to conventional exercises in improving balance and gait speed but improvement in gait symmetry is not changed by additional trunk stabilization exercises except improvement in step length and stride length of non paretic side of limb. So trunk stabilization exercises can be incorporated to improve balance but when gait correction or symmetry is the goal of management, trunk stabilization exercises might not be that effective.

Limitations: (1) Long term effect of the intervention was not assessed. (2) Neither the patients nor the physiotherapists who delivered the interventions were blinded. (3) Small sample size, recruitment of subjects

from single geographical location and lack of randomization leads to poor generalization of study finding amongst stroke population.

**Implications:**

The study showed positive effect of trunk exercises on trunk control and selective trunk movement as assessed by TIS, on functional scale such as BBS, step length-stride length on non-paretic side, cadence and Gait-speed. For a better gait symmetry, and achieving other spatial-temporal parameters, the paretic lower-limb should be treated and gait training should be incorporated to achieve gait symmetry.

**References:**

15) Geert Verheyden, PhD, Luc Vereeck, MSc, Steven Truijen, Additional Exercises Improve Trunk Performance After Stroke: A Pilot Randomized Controlled Trial. Neurorehabilitation and Neural Repair Volume 23 Number 3 March/April 2009 281-286 © 2009 The American Society of Neurorehabilitation.