Effect of computerised targeted visual biofeedback exercises on balance in stroke patients

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Abstract
Stroke is an acute onset of neurological dysfunction due to an abnormality in cerebral circulation with resultant signs and symptoms that corresponds to involvements of the focal areas of brain. Stroke results into decreased proprioceptive sense and muscle strength which leads to impaired balance. Hence in this study, two visual biofeedback exercises were selected to find out the effect on balance in stroke patients. 26 subjects fulfilling the inclusion criteria were selected and divided into control (n=13) and experimental (n=13) groups. Pre intervention step test was measured. The exercise regime protocol was same for both the groups except the control group underwent visual biofeedback exercises in parallel bars in front of the mirror and the Experimental group underwent computerised targeted visual biofeedback exercises for 5 sessions/week for 4 weeks. Step test was reassessed at the end of 4th week. Data analysis was done by using paired and unpaired t-test where p value was <0.005. The results of the present study showed that there was no significant difference in the post step test values of experimental group when compared to the control group. Both the groups showed improvement in the post intervention step test scores. So, it can be concluded that both the visual biofeedback exercises were equally effective to improve the balance in stroke patients.

Keywords: Stroke, Balance, Step test, Biofeedback, Computerized Targeted exercises.

Introduction
Stroke is an acute onset of neurological dysfunction caused due to an abnormality in cerebral circulation with resultant signs and symptoms that corresponds to involvements of the focal areas of brains.[1] Stroke results into decreased proprioceptive sense and muscle strength which leads to asymmetry of the gait and impaired balance.[2,3] Balance is essential to all functional activities during sitting and standing.[4,5] Postural control is fundamental to maintain balance.[4,6] Decrease in balance ability can cause frequent falls due to secondary functional disorder, which includes muscle weakness, sensory defects, gait disturbances, cognitive functions and spatial sense.[7]

After stroke, the recovery of balance and gait is considered to be of crucial importance to achieve autonomy in activities of daily living. More than 85% of survivors can eventually walk with or without assistance.[8] Bio- feedback exercises, in which visual or auditory feedback is provided while balance activities are performed, is one of those treatment programs that fully engage the patient during rehabilitation. It is observed that visual feedback forces the stroke patients to become more aware of their weight bearing asymmetry and will help them to become more symmetrical.[9-11]

Biofeedback plays an important role for patients with balance disorders. The visual and perceptual elements of biofeedback have been said to be effective for stroke patients having difficulties in understanding the locational relationships between objects and spaces to improve balance.[12,13] Treatment using biofeedback is advantageous in diverse environments that can be provided to cause changes in sensory inputs thereby enhancing treatment effects for stroke patients. Motivation for task accomplishment and active participation are enabled through diverse feedback mechanisms, and patients can be intensively trained on diverse target tasks necessary for the improvement of their functions.[12]

Falling is one of the most common complications of stroke patients. Falling can lead to reduction in independence of activities of daily living such as eating, bathing, dressing, toileting, and transferring etc. Improving balance helps in prevention of falls and reduces morbidity. Many studies have been performed to find out the effect of visual biofeedback exercises while performing on force plates, treadmills, bicycle, wi-fit, Balance Master board etc. but there is a dearth of literature on effect of computerised targeted visual biofeedback exercises in improving balance in stroke patients. In the present study, an attempt is made to find out the effects of computerised targeted visual biofeedback exercises on balance in stroke patients.

Materials and Methods
Permission to conduct research was taken from the Institutional Ethical Committee.

Inclusion Criteria
Post stroke subjects with the duration of 3-6 months, medically stable, able to walk at least 10m independently, able to climb up the step independently.

Exclusion Criteria
History of previous CVE (H/O second incident of stroke), neurological disorder other than stroke, co-morbid disabilities that would limit mobility and hinder proper assessment, cognitive dysfunction.

Methodology
26 Subjects fulfilling the inclusion criteria were selected and divided into control and experimental groups. Pre and post intervention step tests were done for both the groups.

Step Test
The step test is a reliable and valid tool for measuring balance.[14] The step test measured the number of times a

subject was able to place one foot on a step with height of 7.5 cm and back to the ground, as fast as possible, within 15 seconds.[14] The score of the step test was recorded for the affected limb. Three trials were performed with 1 minute of rest period between the trials. The subject stepped up with the affected limb followed by unaffected limb on the step and stepped down with affected limb followed by unaffected limb. Subjects performed the test without any assistance. Subjects in both the groups underwent institutional physiotherapy protocol along with the visual biofeedback exercises in parallel bars for control group and computerised targeted visual biofeedback exercises for experimental group. Institutional physiotherapy protocol consisted of strengthening exercises of lower limbs (10 minutes), trunk stability exercises (10 minutes), standing balance training (15 minutes) and functional re- education- Sit to Stand Facilitation (10 minutes).

Control group subjects performed hip and knee flexion alternately with both the limbs in the parallel bars in front of the mirror (Fig. 1 and Fig. 2) and experimental group performed targeted rhythmic hip – knee flexion exercises in front of the computer monitor. In experimental group, the sensors were attached laterally to the midpoint of an imaginary line passing through the greater trochanter and lateral condyle of the femur and over the tibial plateau of each limb respectively. The task was to put the balls into rings which was displayed on the monitor and which was achieved only when the desired hip and knee flexion ROM was achieved by the subject (yellow ball in the yellow ring when subjects flexed his right hip and knee and blue ball in blue ring when subject flexed his left hip and knee) (Fig. 3 and Fig. 4).

The session was of 15 minutes consisting of 6 minutes of exercise followed by 3 minutes of rest and again 6 minutes of exercise for both the groups. The frequency of the exercise session was 5 sessions/week for 4 weeks. Post intervention step test score were reassessed at the end of the 4th week.

Fig. 1: Subject performing alternate hip and knee flexion with the affected limb

Fig. 2: Subject performing alternate hip and knee flexion with the unaffected limb

Fig. 3: Subject hitting the target with the affected limb

Fig. 4: Subject hitting the target with the unaffected limb

Table 1: Paired t test statistics of the pre and post step test scores of the affected limb in the control group

Control group affected limb	Mean	Standard deviation	Standard error mean	Standard error difference	t-value	p-value
Pre step test score of affected limb	2.42	1.04	0.29	0.154	7.50	p<0.005
Post step test score of affected limb	4.08	0.86	0.24			

Table 2: Paired t test statistics of the pre and post step test scores of the affected limb in the experimental group

Experimental group affected limb	Mean	Standard deviation	Standard error mean	Standard error difference	t-value	p-value
Pre step test score of affected limb	3.08	0.76	0.21	0.140	9.8590	p< 0.005
Post step test score of affected limb	4.46	0.88	0.24			

Table 3: Unpaired t test statistics of change in the mean step test scores of control group VS experimental group

Control group vs experimental group affected limb	Mean	Standard deviation	Standard error mean	Standard error difference	t-value	p-value
Control Group	1.15	0.55	0.15	0.208	1.1078	p >0.005
Experimental group	1.38	0.51	0.14			

Results

A highly significant difference was seen when the pre mean step test score 2.42±1.04 steps/15 seconds was compared with the post mean step test score 4.08±0.86 steps/15 seconds of the affected limb of the control group with a p <0.005. Also, a highly significant difference was seen when the pre mean step test score 3.08±0.76 steps/15 seconds was compared with the post mean step test score 4.46±0.88 steps/15 seconds of the affected limb of the experimental group with a p < 0.005. However, no significant difference was found in the mean increase step test score 1.15±0.55 steps/15 seconds of the control group when compared with the mean increase step test score 1.38±0.51 steps/15 seconds of the experimental group with the p> 005 (Table 1-3).

Discussion

In the present study, a total of 26 subacute stroke patients were selected and divided into control and experimental groups. The control group subjects underwent visual biofeedback exercises in front of the mirror and the experimental group subjects were given computerised targeted visual biofeedback exercises. Apart from the visual biofeedback exercises, both the groups were given the institutional physiotherapy protocol for stroke. Balance in both the groups was evaluated before starting the intervention and at the end of 4th week, using step test.

The results showed an improvement in post intervention step test scores of affected limb in both control group and experimental group when compared with the pre intervention step test scores. Due to abnormal postural control, stroke patients show a large postural sway when moving their weight and show reduced ability to maintain stable postures within bearing surfaces. As a result, their reduced balance ability restricts the functional activities.[12] Lower-extremity muscles consist of muscle spindles or proprioceptive sensory receptors that have sensitive receptors, such as the Golgi tendon organ. Also, proprioceptive sensory stimuli provide stance information and necessary segmental movements for the motor control system and when movement of a single joint occurs, the strength of the activated muscles also changes according to that angle.[15]

Biofeedback therapy, in which visual feedback is provided while balance activities are performed, is one of the treatment programs that fully engages the patient during the rehabilitation.[9-11] Visual biofeedback exercises increase the sensory input and muscle activation of affected lower extremity and improve the asymmetric weight bearing towards more symmetrical distribution.[15] The results of the present study were similar with the results obtained by Ji Hye Jung et al who concluded that single-leg stance on the paretic side with knee flexion and extension increases symmetry in weight bearing during stance phase time.[15]

The subjects in the control group performed hip and knee flexion exercise with alternate limbs in front of the mirror in parallel bars. Visual feedback exercises when performed in front of the mirror, by observing the reflected image in the mirror along with the verbal cues, correction in joint position can be achieved.[16,17] Visual feedback from a mirror helps in learning accurate motions through adjustment of errors observed during task performance.[16] Computerised visual biofeedback exercise is a task oriented exercise. Task oriented exercise helps to improve somatosensory integration by stimulating awareness of movement and orientation of the body in the space, it improves proprioception by improving balance.[1]

The results of the study by Kim et al who concluded that visual feedback training enhanced the weight distribution rate of the paretic side of the patients and gait velocity of the patients. Van Peppen et al reported that when balance training using general physical therapy and visual biofeedback were implemented, biofeedback- based balance training showed significant results in increasing the weight distribution rates and temporal variables there by improving the balance.[18]

However, when the mean increase in step test scores 1.15±0.55 steps/15 seconds of the control group was compared with mean increase step test scores 1.38±0.51

steps/15 seconds of the experimental group, no significant difference was found. A study carried out by Walker compared conventional physical therapy with physical therapy combined with visual biofeedback on patients following stroke and found no significant differences between groups, as both exhibited motor improvements, as determined by the three measures employed–the Berg Balance Scale, TUGT, and Gait Speed test.[19] Geiger compared conventional physical therapy with visual biofeedback in hemi paretic patients and found no differences between interventions, as determined by the Berg Balance Scale and TUGT.[20] Both the studies used the Balance Master program as the visual biofeedback. Multicentric study on a larger population is desirable.

Conclusion

Improvement was seen in the post intervention step test scores in both the groups. Results of the present study shows that visual biofeedback exercises in front of mirror and computerised targeted visual biofeedback exercises were equally effective in improvement of balance in stroke patients.

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Conflict of Interest: None.

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