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Research Paper

# Effects of Forceplatform Biofeedback versus Mirror Biofeedback on Balance in Stroke patients.

Medical Science

**KEYWORDS :** Stroke, Balance, Mirror, Biofeedback, Forceplatform biofeedback, Stance symmetry (SS).

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## ABSTRACT

*Aim: A balance retraining on force platform biofeedback system or mirror biofeedback were used to improve balance in stroke patients. Methodology: The therapy session consisted of 45 minutes of conventional balance exercise program and an additional 15 to 20 minutes of biofeedback training (1 hour) for group one & two and for group three no additional biofeedback training was given. The therapeutic interventions (exercise + biofeedback) were given 4-5 times a week, 1 time in a day, the total period was of 4 weeks. Results: The mean values for pre and post intervention of FRT for group one were 13.12+2.10, 24.8+3.35 and 13.06+1.93, 19.68+1.33 for group two respectively, then p value was found to be 0.001. Similarly mean values for pre and post intervention of FRT for group 2 were 13.06+1.93, 19.68+1.33 and 13.37+37, 16.62+2.29 for group 3 respectively, then p value was found to be 0.05. The mean values for pre and post intervention of FRT for group 1 were 13.12+2.10, 24.8+3.35 and 13.37+37, 16.62+2.29 for group 3 respectively, then p value was found to be 0.00. Conclusions: There is significant difference between the effectiveness of the forceplatform biofeedback and the mirror biofeedback for improving balance in stroke patients. Biofeedback provided through forceplates is better for improving balance than mirror biofeedback.*

## INTRODUCTION

World Health Organisation (WHO,2005) defined stroke as 'the rapid development of clinical signs and symptoms of a focal neurological disturbance lasting more than 24 hours or leading to death with no apparent cause other than vascular origin'. A variety of deficits have been seen associated with stroke including loss of sensory, motor and cognitive functions. There are changes in the consciousness level and impairments of the perception and language functions as well. The motor symptoms may manifest as paralysis (hemiplegia) or weakness (hemiparesis) on the opposite side of the body. Hemiparesis is most frequent neurological deficit after stroke.[2] Hemiparetic stroke patients usually suffer balance problems and abnormalities. Balance can be defined as the state of physical equilibrium (maintenance of one's centre of gravity) achieved when vestibular, visual and somatosensory information is integrated in the central nervous system (CNS) and fed through an intact musculoskeletal system.[3] Balance involves the perception and integration of sensory inputs, planning and execution of movements, to achieve a goal requiring upright posture.[4,5] Balance abnormalities in hemiparetic patients after stroke can be linked to different impairments in the physiological system involved in postural control that includes sensory afferents, movement strategies, biomechanical constraints, cognitive processing, and perception of verticality.[6] There are impairments in steadiness, symmetry, and dynamic stability following stroke.[7]

There has been usage of numerous force platform systems for retraining of balance function in patient population, including stroke patients.[1] Force platform system can also be used to provide biofeedback regarding balance to the patients. However, there is insufficient literature related to it. Literature review reveals that mirror therapy has been found to be an effective tool in the rehabilitation of stroke patients. Mirror therapy has been used for posture correction.[8] however, there is a gap of knowledge regarding the comparative efficiency between the two biofeedbacks i.e forceplatform and mirror.

## METHODS

**Subjects:**

A total of 24 subjects were selected on the basis of inclusion and exclusion criteria after signing the informed consent. (8 for conventional balance program plus force platform biofeedback, 8 for conventional balance program plus mirror biofeedback for balance and the remaining 8 for only conventional balance program without any form of biofeedback).

Subjects included were sub acute stroke patients( 3 to 6 months post stroke) recruited from hospital OPD between 8:30 am to 1 pm after approval from the institutional ethical committee of Jamia Hamdard, New Delhi was sought. Subjects meeting inclusion and exclusion criteria were selected for the study. They were informed in detail about the type and nature of the study, the consent was taken prior to the study. Forceplatform system of mtd-Balance version 5.1 was used for analysis of load and symmetry and for balance biofeedback. The instrument balance platform consists of two dual force plates mounted on a pair of symmetrically positioned force transducers. A mirror was utilized to provide biofeedback. It should allow the whole body visualization for the patient.

**Protocol:**

The following measurements were taken at baseline in all 3 groups. First, the subject's functional reach test score was noted. A yard stick is attached to a wall at about shoulder height. The subject is positioned infront of this so that upon flexing the shoulder to 90 degrees, an initial reading on the yardstick can be taken. The examiner takes a position 5-10 feet away from the patient, viewing the patient from the side. Position the patient close to the wall (normal side) so that they may reach forward along the length of the yardstick. The subject is instructed to stand with feet shoulder distance apart, then make a fist and raise the arm up so that its parallel to the floor. At this time, the examiner takes an initial reading, usually spotting the knuckle of the third metacarpal. Then the patient is instructed to reach forward as much as possible without moving the feet. Reading was then taken on the yardstick of the farthest reach attained by the subject without taking a step. The initial reading is then

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subtracted from the final to obtain the functional reach score. Secondly, the subjects were asked to perform the timed up and go test.

The subjects was asked to sit correctly in a chair, with the subject's back resting on the back of the chair. The chair should be stable and positioned such that it will not move when the subject moves from sitting to standing. A marker is placed on the floor 3 meters away from the chair so that it is easily seen by the subject. The subject is instructed to stand up and go when the commands are given. The subject is asked to walk up to the marker, turn around and walk back to the chair and sit down. The subject has to walk at normal pace. Timing is started on the word "go" and stopped when the subjected is seated again correctly in the chair with their back resting on the back of the chair. The total time is noted.

And finally, stance symmetry was measured using forceplatform system in habitual stance mode.

**Habitual Stand (time of measurement 10 sec.):**
The subjects were asked to stand comfortably on the two platforms facing the desktop. The distance between the force plates and the computer screen was adjusted according to the patient's sight. Patient was made sure that he/she could easily and clearly see the instructions on the computer screen.

The patient was then asked to switch his weight 2-3 times from the left to the right leg– then he/she has to find a comfortable standing position. When the patient stands still, the measurement process starts. Then the patient has to remain in that position until the measuring process is complete. Then, the data can be obtained from the force platform system in a tabular form as well.

**Training:**
The therapy session consisted of 45 minutes of conventional balance exercise program and an additional 15 to 20 minutes of biofeedback training (1 hour) for group 1& 2 and for group 3 no additional biofeedback training was given. The therapeutic interventions (exercise+biofeedback) were given 4-5 times a week, 1 time in a day. This was given for a period of total of 4 weeks.

**Statistical Analysis:**
All the data are presented as mean±SD. Independent t-test was used for within group analysis and one way ANOVA was used for between group analyses**.** The results were taken to be significant if $p<0.05$.

**RESULTS**
Table 1 and Table 2 details the results of present study. The mean values for pre and post intervention of FRT for group one were 13.12+2.10, 24.8+3.35 and 13.06+1.93, 19.68+1.33 for group two respectively (p value was found to be 0.001, which is lesser than 0.05, hence, FRT was found to be statistically significant between group one and group two post intervention. F value was 0.52 for pre intervention measurements of FRT and 22.78 for post intervention measurements taken after 4 weeks).

The mean values for pre and post intervention of FRT for group 2 were 13.06+1.93, 19.68+1.33 and 13.37+37, 16.62+2.29 for group 3 respectively (p value was found to be 0.05, FRT was found to be statistically significant between group 2 and group 3 post intervention. F value was 0.52 for pre intervention measurements of FRT and 22.78 for post intervention measurements taken after 4 weeks).

The mean values for pre and post intervention of FRT for group 1 were 13.12+2.10, 24.8+3.35 and 13.37+37, 16.62+2.29 for group 3 respectively (p value was found to be 0.00, which is lesser than 0.05, hence, FRT was found to be statistically significant between group 1 and group 3 post intervention. F value was 0.52 for pre intervention measurements of FRT and 22.78 for post intervention measurements taken after 4 weeks).

The mean values for pre and post intervention of SS for group 1 were 23.75±7.49, 2.50±1.77 and 19.75±5.59,6.75±3.37 for group 2 respectively (p value was found to be 0.116, SS was found to be statistically insignificant between group 1and group 2 post intervention. F value was 0.72 for pre intervention measurements of SS and 14.87 for post intervention measurements taken after 4 weeks).

The mean values for pre and post intervention of SS for group 2 were 19.75±5.59,6.75±3.37 and 21.50±6.21,13.50±5.92 for group 3, respectively (p value was found to be 0.009, SS was found to be statistically significant between group 2 and group 3 post intervention. F value was 0.72 for pre intervention measurements of SS and 14.87 for post intervention measurements taken after 4 weeks).

The mean values for pre and post intervention of SS for group 1 were 23.75±7.49, 2.50±1.77 and 21.50±6.21,13.50±5.92 for group 3, respectively (p value was found to be 0.00, SS was found to be statistically significant between group 1 and group 3 post intervention. F value was 0.72 for pre intervention measurements of SS and 14.87 for post intervention measurements taken after 4 weeks).

**DISCUSSION**
Stance symmetry is an indicator of static balance and describes the equal weight distribution between the feet in the standing position. The result was found to be statistically significant in within group analysis of all the three groups. This means that there was improvement in the weight distribution between the lower limbs in all patients regardless of the group. Possible explanation for such kind of findings could be related to the fact that repetitive motor training improves the motor performance that results in better motor learning of the task. As our patients were made to practice equal weight distribution through weight shift training, it is believed that repeated task-specific protocols induced brain reorganization that facilitated the excitatory pathways that brought an improvement in functional performance9. Such training may also lead to permanent structural plastic changes in the brain in a long run. These findings are consistent with the work done by Goddard et al, 2009, whereby they concluded that force platform biofeedback was found to significantly improve the stance symmetry as well as the coordination between the legs. Mirror biofeedback was also reported to bring about the improvements in the SS[10]. Mirror training has been also thought to activate areas within the premotor and somatosensory cortex, and that the frontal motor neuron system is known to facilitate motor output during action observation of movements. Conventional exercises for balance have also been found to improve static components of balance[11]

Further, when between groups analysis was done, the results showed that SS was statistically significant between group 1& 3, with greater improvements in the force platform biofeedback group. This can be explained through a model presented by Mulder12 in 1991 on human motor behavior. It says that there are motor programs stored in the memory that are responsible for providing adequate movement and rehabilitation therapy was the acquisition of programming rules which required three crucial elements: adequate feedback, variability of practice, and design of learning situation. After stroke, it has been seen that intrinsic feedback systems may be compromised, making it difficult for the person to determine what needs to be done to improve performance. Extrinsic feedback may thus be helpful in providing such information to the stroke patients.13. Therefore,

it was suggested that provision of knowledge of results may allow explicit memory (knowledge of facts, events, and episodes) to assist motor learning in these patients.14. Force platform biofeedback provided them the required information as well as there were variations in the practice which were not provided by routine conventional balance exercises. Because the tasks were new to patients, adequate and consistent feedback as well as clear instructions resulted in positive phenomenon of motor learning. The findings of the study are also supported by Nichols Deborah et al, they concluded that stance weight bearing was more symmetric after visual feedback training when compared with conventional therapy. Reinforcement and repetition resulted in the retention of a meaningful patterned movement. Thus better improvements were observed in forceplatform biofeedback group.

Mirror biofeedback along with conventional exercises was also found to be superior in efficacy than conventional exercises alone in the present study. As already discussed, the provision of extrinsic biofeedback via forceplatform and mirror might have attributed to the improvements in SS that were found to be more evident in group 1 and 2 as compared to group 3.

Results show that SS was statistically insignificant between groups 1&2. A common factor of conventional exercises was included in both the groups, in addition to the biofeedback training, might be a probable reason for such a finding. However, on comparing the mean percentage change (difference/original value×100) from pre to post intervention, the force platform biofeedback group showed 89% improvement in SS, in contrast to just 64% improvement with mirror biofeedback. Based on this particular finding, we may say that force platform biofeedback group yielded better outcome than mirror biofeedback. Probable explanation for this could be that in force platform biofeedback group, a task oriented or a goal directed approach, which was far more challenging for the patient than to just stand infront of the mirror and maintain proper posture, was given. . Patients were fully cognitively engrossed during the force platform training. Such a high demanding approach was not followed in group 2&3. Because it has been suggested that practice conditions that promote additional cognitive effort or require the learner to engage in additional information processing activities that are critical for test performance are most effective for learning.15 This may be a reason that resulted in better motor learning of the task in group 1.

Moreover, while giving force platform biofeedback, we got an objective and quantitative measure of Stance symmetry readings during the performance of the task, on the basis of which we directed and instructed the patient. Such a facility, which is important for contemporary rehabilitation16, was not available while giving mirror biofeedback to the patient. We also observed more increments in the confidence levels of the patients who received force platform biofeedback. Hence, we may conclude that SS can be trained better using force platform biofeedback than mirror biofeedback.

Based on these findings and their respective explanation, we may say that better outcomes in the static balance (through stance symmetry) can be achieved through force platform biofeedback training than mirror biofeedback.

Study done by Laroia & Hamdani et al, 2012 reported that static balance training has carry over effects on dynamic balance. Their study was on elderly subjects. Hence, two measures for dynamic balance were also taken to study the carry over effects of static forceplatform biofeedback training and static mirror biofeedback training on dynamic balance in stroke patients and also find out the better between the two as a means to improve dynamic balance.

**Functional Reach Test (FRT)**

FRT is an indicator of dynamic balance. The result was found to be statistically significant in within group analysis of all the three groups as well as in between the group analysis of groups 1, 2 and 3. This suggests that static biofeedback training in both groups 1& 2 was effective enough to bring about the improvements in dynamic balance, as measured on FRT ($p < 0.05$).

FRT, although, being an indicator of dynamic balance, also indicates mobility and flexibility at shoulder, hip, ankle and trunk. Because of reduced flexibility at the trunk, stroke patients find difficulty in reaching activities. Weight shifting training in sitting has been found to improve trunk control and mobility17. Our intervention too consisted of weight shifting training. In the present study, weight shifting had been practiced by all the stroke patients regardless of the group in the standing position. This might be a probable reason that FRT has improved in all the groups as the training protocol especially emphasized weight shifting skills, which benefit dynamic balance function more.18 Application of biofeedback has also been found to be effective in enabling an earlier trunk control and is an important component of physiotherapy in rehabilitation of post stroke patients.

The findings of the current study are also supported by Hill and Ellis et al54, 1997 who also found considerable improvement in the FRT scores post intervention consisting of conventional rehabilitation exercises including balance exercises. Furthermore, Ben Yakov, PT, also supported the view that mirror biofeedback can also be used to improve trunk control.

However, in the present study, better FRT scores were documented in group 1. Forceplate biofeedback group subjects maximally practiced weight shifting as the task required them to bear load on the affected side. Unless and until there was equal weight distribution on both the legs, the task would not complete. This provided a challenge to the subjects practicing weight shifting in group 1 which was absent in group 2 or group 3. Thus, the subjects in group 1 practiced with more vigilance (alertness) and sincerity in order to accomplish the task and overcome the challenge. Also, in group 1, the complexity in balance training was further increased after the patients mastered the previous activity assigned to them. It was reflected by less number of errors committed and better scoring. This motivation and interest in the therapy could also have contributed to balance improvement as the patients were subjected to a new task, which was not so in group 2& 3, thus better learning. As such, better outcome was observed.

Results showed that force platform biofeedback was more effective in improving FRT than mirror biofeedback. Thus, it can be concluded that the greater improvements in the FRT can be achieved through force platform biofeedback than mirror biofeedback, both being effective although. As FRT indicates dynamic balance, so through this study, it can also be said that force platform biofeedback, that provides static balance training, is also helpful in improving dynamic function as well.

**Future Research:**

Science is dynamic and there is always a scope of improvement and change in time to come ahead. With the progressive aim to move ahead we aspire to achieve highly accurate and reliable results. Thus, every study leaves back scopes for other researcher to do something more advanced and varied in order to touch the height of perfection.

This study examined only 24 subjects in total and data collection was confined to closed setup with minimum distractible conditions. Thus future researchers can expand the study by including more number of subjects so as to make generalization of results and practice such experiments in variable environmental setups

such as open environment. Thus it could be applied to real life situation. Future research can be conducted on a larger sample size and find the retention of improvements in balance measures by taking follow up measurements. Here, we studied the improvements in the stance symmetry , research can also be conducted on the other quantitative measurements given by forceplatform system such as coordination index, fluctuation index etc.

**Clinical Implication:**

This study has shown forceplatform biofeedback training to be a promising method of improving balance in stroke patients which was found to be more effective than mirror biofeedback. Thus, earlier application of such treatment methods can prove very crucial in preventing the disability, so that a good quality of life can be enjoyed by our patients. Hence, this novel treatment must be inculcated into our therapy program to gain maximum benefit for the patient.

**Limitation**

There are several limitations regarding to the study that,

The study was conducted on a small sample size due to less availability of sub acute stroke patients. 2. Follow up measurements were not taken. 3. Force platform biofeedback was given only to such patients who were able to stand independently without any assistive device.

**CONCLUSION**

The findings of this study support the experimental hypothesis that there is significant difference between the effectiveness of the forceplatform biofeedback and the mirror biofeedback for improving balance in stroke patients. Biofeedback provided through forceplates is better for improving balance than mirror biofeedback. Thus, forceplatform biofeedback can be successfully used in the rehabilitation settings for improving balance in stroke patients.

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**Table 1: Between group comparison of values of TUG.**

| | PRE TUG | POST TUG |
|---|---|---|
| Group 1<br>Vs Group 2 | 47.83±6.35<br>50.40±4.5 | 38.73±8.40<br>45.82±6.2 |
| Mean differences | -2.56 | -7.087 |
| p value | 0.66 | 0.133 |
| Group 2 VS Group 3 | 50.40±4.5<br>47.23±6.61 | 45.82±6.21<br>45.38±6.27 |
| Mean differences | 3.16 | 0.43 |
| P value | 0.54 | 0.99 |
| Group 1 VS Group 3 | 47.83±6.35<br>47.23±6.61 | 38.73±8.40<br>45.38±6.27 |
| Mean difference | 0.60 | -6.65 |
| P value | 0.97 | 0.16 |
| F value | 0.648 | 2.549 |
| P value | 0.533 | 0.102 |

**Table. 2. Between group analysis of values of FRT**

| | Pre test values of FRT | Post test values of FRT |
|---|---|---|
| Group 1<br>Vs Group 2 | 13.12±2.10<br>13.06±1.93 | 24.8±3.35<br>19.68±1.33 |
| Mean difference | 0.625 | 5.18 |
| p value | 0.998 | 0.001 |
| Group 2<br>Vs Group 3 | 13.06±1.93<br>13.3±2.10 | 19.68±1.33<br>16.6±2.29 |
| Mean difference | -0.312 | 3.062 |
| P value | 0.950 | 0.05 |
| Group 1<br>Vs Group 3 | 13.12±2.10<br>13.37±37 | 24.87±3.35<br>16.62±2.29 |
| Mean difference | -0.250 | 8.250 |
| P value | 0.968 | 0.00 |
| F value | 0.52 | 22.78 |
| P value | 0.949 | 0.00 |

**Table. 3. between group analysis of stance symmetry (SS)**

| | Pre test values SS | Post test values SS |
|---|---|---|
| Group 1<br>Vs Group 2 | 23.75±7.49<br>19.75±5.59 | 2.50±1.77<br>6.75±3.37 |
| Mean Differencence | 4.00 | -4.25 |
| p value | 0.466 | 0.116 |
| Group 2<br>Vs Group 3 | 19.75±5.59<br>21.50±6.21 | 6.75±3.37<br>13.50+5.92 |
| Mean difference | -1.75 | -6.75 |
| P value | 0.86 | 0.009 |
| Group 1<br>Vs<br>Group 3 | 23.75±7.95<br>21.50±6.21 | 2.50±1.77<br>13.50±5.92 |
| Mean difference | 2.25 | -11.00 |
| P value | 0.78 | 0.00 |
| F value | 0.724 | 14.87 |
| P value | 0.497 | 0.00 |

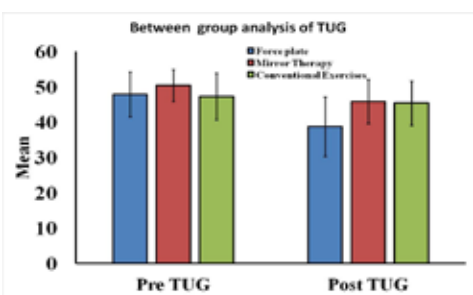


**Fig. 1. Comparison of values of TUG between group.**

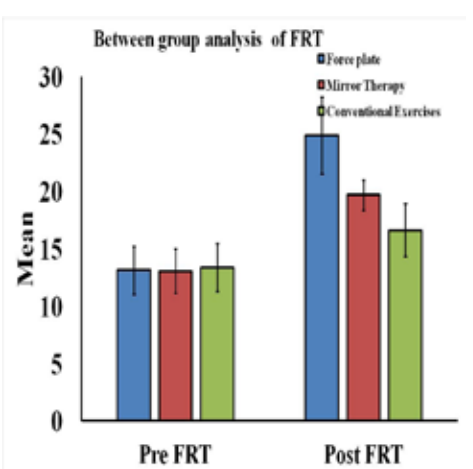


**Fig.2. comparison of values of Functional reach test between group.**

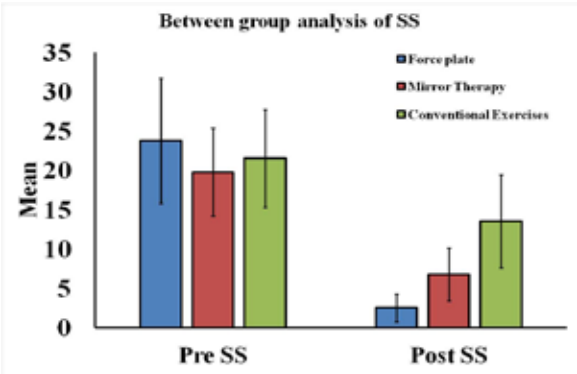


**Fig.3. Comparison of values of Stance symmetry (SS) between Group.**

## REFERENCE

1. Nichols DS. Balance retraining after stroke using forceplatform biofeedback. Journal of American Physical Therapy Association, 1997; 77: 553-558. | 2. Gresham GE, Duncan PW, Stason WB et al. Post stroke rehabilitation: Assessment, Referral & Management. Agency for Health Care Policy and Research, 1995. Pub. No. 95-0563. | 3. Neurological Disabilities. Assessment and treatment (1998). Bennett S.E, Karnes JL. | 4. Goldstone, R.L. (1998), "Perceptual learning", Annual Review of Psychology 49:585-612. | 5. Blum L, Korner N. Usefulness of Berg Balance Scale in stroke rehabilitation. Journal of American Physical Therapy Association, 2008; 88: 559-566 | 6. Oliveira CB, Medeiros IR, Ferreira NA. Balance control in hemiparetic stroke patients: main tools for evaluation. Journal of Rehabilitation Research and Development, 2008; 45:1215-1226 | 7. Horak FB, Esselman P, Anderson ME, Lynch MK. The effects of movement velocity, mass distribution and task certainty on associated postural adjustments made by normal and hemiplegic individuals. Journal of Neurology, Neurosurgery and Psychiatry, 1984; 47: 1020-1028 | 8. Lee MY, Wong MK, Tang FT. Clinical evaluation of new biofeedback standing balance training device. J Med Eng Techno, 1996; 20(2): 60-62 | 9. Nojima I, Mima T, Koganemaru S, Mohamed N. Human Motor Plasticity Induced by Mirror Visual Feedback. The Journal of Neuroscience, 2012; 32(4):1293–1300. | 10. Cheng PT, Shu-Hsia, Liaw MY, Alice M.K et al.Symmetrical body-weight distribution training in stroke patients and its effect on fall prevention. Arch Phys Med Rehabil, 2001; 82: 1650-4 | 11. Alain, Leroux P et al. Task oriented intervention in chronic stroke: changes in clinical and laboratory measures. American Journal of Physical Medicine & Rehabilitation, 2006; 85(10): 820-830 | 12. Mulder T. A process oriented model of human motor behavior: toward a theory based rehabilitation approach. Journal of American Physical Therapy Association, 1991; 71:157-164. | 13. Paulette M. Van V & wulf G. Extrinsic feedback for motor learning after stroke: What is the evidence? Disability and Rehabilitation, July 2006; 28(13 – 14): 831 – 840. | 14. Winstein C, Wing AM, Whitall J. Motor control and learning principles for rehabilitation of upper limb movements after brain injury.Handbook of Neuropsychology Vol. 9 Amsterdam: Elsevier; 2005 | 15. Wulf G, Shea C. Principles derived from the study of simple skills do not generalise to complex skill learning. Psychonomic Bulletin & Review 2002, 9 (2), 185-211. | 16. Krekora K, Czernicki J. Biofeedback in rehabilitation of stroke patients Medical Rehabilitation, 2005; 9(3). | 17. Jung K, Kim Y, Chung Y. Weight-Shift Training Improves Trunk Control, Proprioception, and Balance in Patients with Chronic Hemiparetic Stroke. Tohoku J. Exp. Med., 2014; 232: 195-199 | 18. Cheng PT, Shu-Hsia, Liaw MY, Alice M.K et al.Symmetrical body-weight distribution training in stroke patients and its effect on fall prevention. Arch Phys Med Rehabil, 2001; 82: 1650-4. |