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Research Article

# Comparison of Embedded Versus Added Motor Imagery Training for Improving Balance and Gait in Individuals with Stroke

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**ABSTRACT**

*Introduction:* Residual impairments and functional limitations are the major cause of social restrictions and permanent disabilities in individuals with stroke. Loss of balance and gait are the most important functional disorders of individuals with stroke. Motor imagery (MI) when combined with physiotherapy can offer functional benefits after stroke. Two Motor Imagery integration strategies exist: added and embedded Motor Imagery. Both approaches were compared while learning a complex motor task (MT): 'balance and gait'. *Methods:* patients attending SRM hospital after first stroke participated in a single-blinded, quasi experimental study with Motor Imagery embedded into physiotherapy (group A), Motor Imagery added to physiotherapy (group B). Both groups were participated in ten physiotherapy sessions. The outcome measures used were Berg Balance Scale, Dynamic Gait Index and Visual and Kinesthetic Imagery Questionnaire. The post test was taken after two weeks of intervention. *Results:* 20 individuals with stroke (13 males and 7 females) were included. Both groups showed significant improvement in Balance, Gait and Imagination ($p < 0.05$). No differences were found between group A and group B. *conclusion:* The 2 - week's program of embedded and added motor imagery training was equally effective to train the balance and gait in subjects with stroke. Thus, Embedded or Added Motor Imagery training combined with physiotherapy seems to be beneficial for stroke patients to learn the motor task.

**Keywords**: Stroke, Embedded Motor Imagery, Added Motor Imagery, Balance, Gait.

## INTRODUCTION

Residual impairments and functional limitations are the major cause of social restrictions and permanent disabilities in individuals with stroke[58]. In fact 75% of stroke individuals suffer from disorder involving Activities of Daily Living. Loss of Balance and Gait are the most important functional disorders of individuals with stroke. Between 27% and 50% of community dwelling individuals report difficulty in walking outside of their home for months and years following stroke onset[66]. Balance is an ability to maintain the center of mass within a proximal area and keep a stable posture when moving the body. Gait is a complex behavior, involving coordinated muscle activation and balance control as well as adaptation of movements according to the environment[61,1,52]. It is increasingly recognized that Gait also requires higher level cognitive control, such as attention and executive functions[61,59]. One of the methods to explore this higher order cognitive control of Gait is through neuroimaging technique, using motor imagery paradigms[61]. Motor Imagery (MI) is the mental simulation of the action without its actual execution[60]. The simulations of action and preparation before execution have been attributed to the same motor representation system (Jeannerod, 1994)[33].Motor Imagery activates the neural circuits of premotor cortex, posterior parietal cortex, supplementary motor area, basal ganglia and cerebellum which is similar to the executed movement involved in the early stage of motor control[61,62.] At the beginning of the 21st century, attempts were made to transfer the concept of Motor Imagery from sports psychology to stroke Rehabilitation[1].Page et al. (2001)[67] and Liu et al (2004)[30,32] tried to combine occupational therapy and Motor Imagery to improve motor recovery in patients after stroke or brain injury. Page's concepts can be described as Added Motor Imagery. In this technique, patients after stroke in the subacute and chronic phase listened to a 10minute pre-recorded tape with instructions to imagine movements that were previously practiced during therapy[1,31]. Liu et al. (2004)[30,32] tested a more Embedded Motor Imagery approach during an occupational therapy intervention, rather than Added Motor Imagery, based on pictures showing tasks that have to be imagined over a twoweek period in patients with brain injury and stroke. They were also asked to imagine potential problems in performing the imagined task, to describe the problems verbally, to imagine the problem solving version of the task, and, finally, to perform the corrected task physically after Motor Imagery[1,30]. Embedded Motor Imagery procedure is based on the Physical/Emotion, Timing, Environment and Task/Learning/Perspective - PETTLEP approach that can be summarized as follows:

*Physical/Emotion*

Imagination of the motor act where it should be performed, without any prior relaxation exercises, in an active and alert state.

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Figure 1: kneeling.

Figure 2: Half kneeling.

Figure 3: Stride standing.

Figure 4: walking over obstacles.

Table 1: Motor tasks and comments.

| Motor tasks | Comments |
|---|---|
| Kneeling | Non affected hand on the chair without arm rest. |
| Half kneeling on mat | Non affected hand on the chair without arm rest and kneel on affected leg. |
| Stride standing | Non affected hand on the chair without arm rest with un affected leg in front. |
| Tandem standing | One foot in front of other foot. |
| Single limb stance on wedge | Forward stepping and reaching with affected leg placed on wedge. |
| Obstacle walking | Walking over the obstacle. |
| Balance beam walking | Walking on balance beam. |

*Timing*

Duration of the motor task should not exceed the real performance duration.

*Environment*

Using (personalized) multisensory environmental cues.

*Task/Learning/Perspective*

Depending on the patient's learning type and its familiarization with the task, external or internal perspective is chosen[1,27]. Several Rehabilitation methods used for stroke patients addressing patient recovery are based on motor learning or Neuro-developmental approaches[39-44]. Recently new Rehabilitation approaches have been reported in the management of stroke patients, e.g. robot-aided[45], virtual reality rehabilitation[46], and Motor Imagery[30]. Motor Imagery does not require expensive technology, equipment, instrumented locations, and it does not physically exhaust the individual[47]. After initial learning, the Motor Imagery technique can be practiced by the patient independent from the therapist, location, and time of the day. Recently, Embedded focused Motor Imagery interventions have become more popular. Motor Imagery is integrated into therapy routines in Rehabilitation centers[1,29]. Literatures involving the use Embedded and Added Motor Imagery approaches for improving Balance and Gait are limited. So, this study attempts to find the effect of Added and Embedded Motor Imagery to improve Balance and Gait in individuals with stroke.

## MATERIAL AND METHODS

The study was conducted in SRM University, Chennai. Patient attending the institute with age group (40 to

Table 2: Motor imagery training sessions.

| Motor Imagery Training Session Element | Motor imagery training session elements for embedded motor imagery | Motor imagery training session elements for added motor imagery |
|---|---|---|
| Integration of Motor Imagery (embedded & added). | Embedded into physiotherapy session. | Added after physiotherapy session. |
| Session. | Individual. | Individual. |
| Supervised by an instructor. | Supervised. | Not supervised. |
| Location of Motor Imagery Training Session. | Task specific physiotherapy during session. | Non task specific after physiotherapy session in separate room. |
| Instruction medium. | Spoken instruction directly from therapist. | Spoken instruction from therapist on audiotape. |
| Instruction mode. | Live. | Prerecorded. |
| Eyes. | Closed. | Closed. |

Table 3: Comparison of pre and post treatment measure for group A – subjects trained with Embedded Motor Imagery training.

| Group a | Median pre | Median post | Z | Significance |
|---|---|---|---|---|
| DGI | 11.00 | 15.50 | -2.823 | 0.005** |
| BBS | 41.50 | 51.00 | -2.812 | 0.005** |
| VIQ | 44.50 | 72.00 | -2.805 | 0.005** |
| KIQ | 38.00 | 63.00 | -2.814 | 0.005** |

Table 4: Comparison of pre and post treatment measures for group B - subjects trained with Added Motor Imagery training.

| Group b | Median pre | Median post | Z | Significance |
|---|---|---|---|---|
| DGI | 10.50 | 16.00 | -2.848 | 0.004** |
| BBS | 41.00 | 49.50 | -2.820 | 0.005** |
| VIQ | 45.00 | 71.50 | -2.812 | 0.005** |
| KIQ | 38.00 | 63.00 | -2.810 | 0.005** |

(**$P \leq 0.05$), (***$P > 0.05$)

65years) with middle cerebral artery involvement who had single stroke occurred at least less than 6 months (once the subjects become medically stable) with Brunnstrom stages 4 & 5 and able to stand with or without cane for 30 seconds on normal hard floor and can able to walk for about 10 meters with or without cane with score at least 20 in Mini Mental State Examination were identified as potential participants. Exclusion criteria were: Transient Ischemic Attack, pain limiting the motor task, undergone joint replacement, with limited range of motion in the joints, Subjects who are obese, having visual and cognitive dysfunctions. Written informed consent forms were obtained after the purpose of the study had been explained. Baseline assessment and post assessment were taken by other therapist who was blinded about study. Recruited participants were assigned alternatively to group A (Embedded Motor Imagery Training) and group B (Added Motor Imagery Group). Initial demographic data and clinical information was collected including age, body mass index, vital signs, duration of stroke, Minimental State Examination and a detailed physical evaluation was carried out. Assessment was carried out by other examiner who doesn't know about the study in a cubicle. Each participant was assessed for two times: base line and post therapy (i.e. after 2 weeks of therapy). The following scales were assessed during each assessment.

*Berg Balance Scale*

Berg balance scale (BBS) is an objective measure of balance abilities. This tool relates to meaningful activities of daily living like sit to stand, variations in standing positions, transfer, turning and other balance activities. This scale consists of 14 functional tasks commonly performed in everyday life. Scoring uses five point ordinal scale, with scores ranging from 0– 4.

*Dynamic Gait Index*

The Dynamic Gait Index (DGI) was to evaluate functional stability during gait activities in older people and to evaluate their risk of falling. The DGI includes 8 items such as walking while changing speed and turning the head, gait with pivot turn, walking over and around obstacles, and stair climbing. The scoring of the DGI is based on a 4-point scale ranging from 0 to 3.

*Kinesthetic and Visual Imagery Questionnaire*

Kinesthetic and Visual Imagery Questionnaire (KVIQ) is to assess patients' Motor Imagery vividness. It consist of 20 items, subscales of the affected side should compared to the non-affected side. The scoring of KVIQ is bases on five point Likert scale ranging from 1 – 5. All participants received standardised physiotherapy treatment based on a mixed neuro-physiological and motor learning approach (Pollock A et al 2007) depending on the motor level of the participants for improving Balance and Gait. Total treatment time for two groups was about 45 to 50 minutes. Care was provided by multidisciplinary team including neurologist, physiotherapist and occupational therapist at hospital care.

*Motor Task*

Table 5: Comparison of post test values of Dynamic Gait Index, Berg Balance Scale, Kinesthetic and Visual Imagery Questionnaire between group A subjects trained with using Embedded & group B subjects trained with Added Motor Imagery training.

| Scale | *Group A | *Group B | Median | Z Value | Significance |
|---|---|---|---|---|---|
| | Post median | Post median | | | |
| DGI | 15.50 | 16.00 | 16 | -0.231 | 0.817*** |
| BBS | 51.00 | 49.50 | 50 | -0.799 | 0.424*** |
| VIQ | 72.00 | 71.50 | 72 | -0.538 | 0.590*** |
| KIQ | 63.00 | 63.00 | 63 | -0.876 | 0.381*** |

All participants had to perform Motor Task on Balance and Gait once per day for 10 days and additionally once for the baseline measurement and then for post test measurement. The total performances were twelve for each subject. Subjects were free to select their foot placement in front during stride standing, half-kneeling. The motor tasks were practiced only once during physiotherapy session in both study groups and the subjects were advised not to practice the motor task more than once, in a different order, or parts of the motor task. Participants were asked not to practice the motor task at home during the intervention period.

*Experimental Group A (Embedded Motor Imagery)*

The Motor Imagery intervention will be embedded in physiotherapy of the ten therapy sessions which last for 45 minutes each. Each stage will be imagined five times before it is physically practised once. At each physiotherapy session, subjects have to imagine the complete task four times during walking and then standing against the wall.

*Experimental Group B (Added Motor Imagery)*

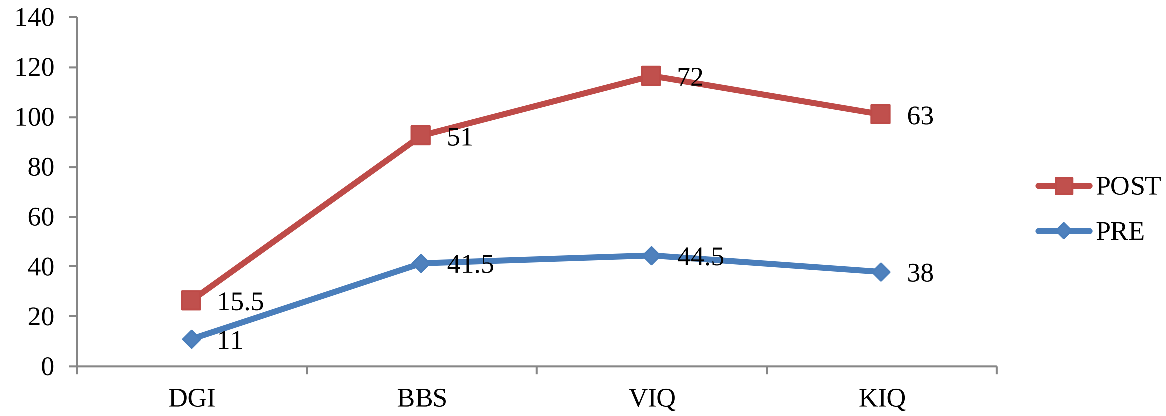
After standardized physical therapy there will be Added Motor Imagery training. Here the subject should listen the Mobile/CD consist of Relaxation period (3.5 minutes), Description of each motor task stage and will be instructed to imagine the complete task as often as possible (14.5 minutes), Refocus of the situation and the room in short period (2minutes) in the separated, quite room.

## RESULTS

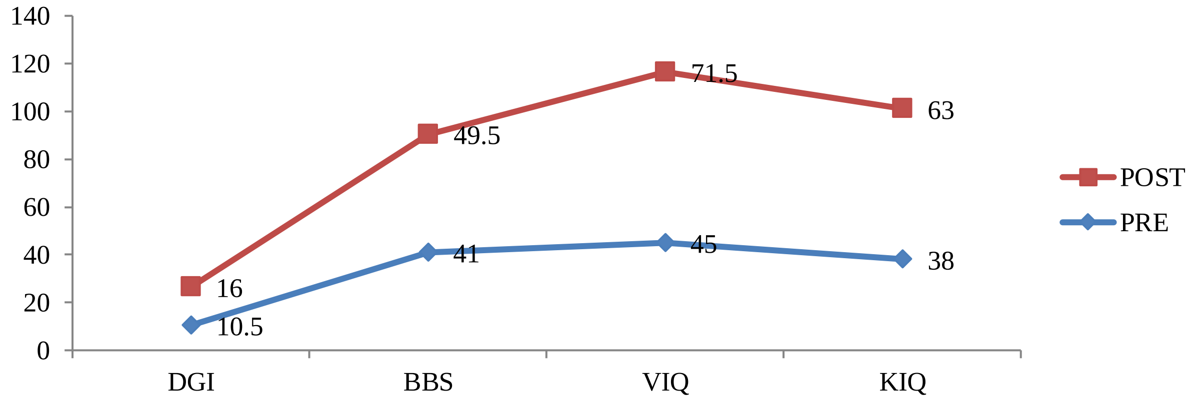
The collected data were tabulated and analyzed using descriptive and inferential statistics. Median was used to assess all the parameters of the data using statistical package for social science (SPSS) version 20. Wilcoxon singed rank test was adopted to find out the effect of all parameters within Embedded and Added Motor Imagery training. Mann Whitney U test was used to compare the changes in all mean values of all the parameters between Embedded and Added Motor Imagery Training group. Pair-wise comparison of Embedded group (table. 3) showed that there were statistically significant difference in Dynamic Gait Index, Berg Balance Scale and Kinesthetic and Visual Imagery Questionnaire between pre and post test within group which denotes that there was a significant improvement in Dynamic Gait Index, Berg Balance Scale and Kinesthetic and Visual Imagery Questionnaire after Embedded Motor Imagery Training in stroke subjects. In the Added group (table. 4) there was a statistically significant difference in Dynamic Gait Index, Berg Balance Scale and Kinesthetic and Visual Imagery Questionnaire between pre and post test within group B which denotes that there was a significant improvement in Dynamic Gait Index, Berg Balance Scale and Kinesthetic and Visual Imagery Questionnaire following Added Motor Imagery Training in stroke subjects (graph 1 & 2). According to table 5 there was no significant difference between post test values of Dynamic Gait Index, Berg Balance Scale and Kinesthetic and Visual Imagery Questionnaire between the groups which denotes that there is a significant difference between both groups (graph 3).

## DISCUSSION

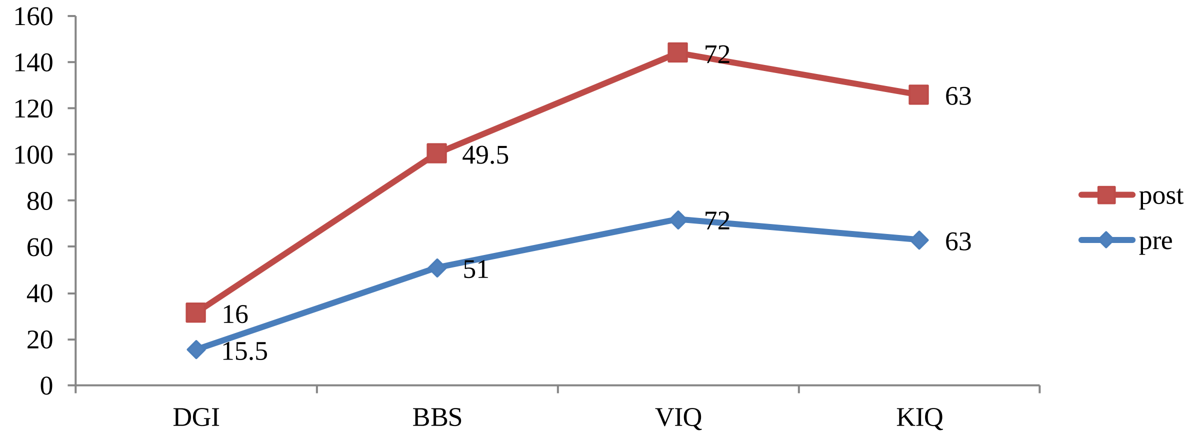
This study was done to compare the effect of Embedded and Added Motor Imagery approaches in training Balance and Gait in individuals with acute or sub-acute stroke. The values of Berg Balance Scale, Dynamic Gait Index and Kinesthetic and Visual Imagery Questionnaire were compared for the subjects in both the groups. The results showed significant improvement in balance, gait and imagination among the subjects in both the groups (Embedded and Added imagery approach) indicating that the two interventions were effective in improving motor activities in the sample studied. However, on comparing the values of Berg Balance Scale, Dynamic Gait Index and Kinesthetic and Visual Imagery Questionnaire between these two groups, no significant difference was found. Motor Imagery has its origin in the sports psychology and behavioral psychology in the end of the 19th century[48]. Several theories are proposed to explain the neuro-physiological mechanisms of Motor Imagery. The 'psycho neuromuscular theory' was proposed by Jacobson in the early 1930s based on the detection of myoelectrical changes related to the imagined movement[49]. Another theory is based on co-location of brain activation during imagined and real movements in healthy individuals[50–52] as well as in stroke patients[53,54]. Findings from functional MRI studies provide the neuro-physiological basis of current Motor Imagery training interventions. Brain areas activated during Motor Imagery and real movements show a strong congruity for single arm movements as well as complex whole body movements in stroke subjects[35,36]. Similar findings were made for other neurological disorders like Parkinson and amyotrophic lateral sclerosis[37,38]. Intervention studies confirmed a beneficial effect of Motor Imagery in patients after stroke. Moreover, these results were confirmed in further patient groups, including traumatic brain injury, multiple sclerosis, and Parkinson[30,55,56]. The study revealed that the post test scores of Dynamic Gait Index, Berg Balance Scale and Kinesthetic and Visual Imagery Questionnaire score was higher than the pre test values while comparing both and it



Graph 1: Embedded Motor Imagery training.



Graph 2: Added Motor Imagery training.



Graph 3: Comparison of embedded and added motor imagery.

was significant at p<0.05 level in Embedded Group. This study is in line with the study by Susy M Braun (2007) who compared the Embedded Motor Imagery training in daily therapy to the therapy as usual in adult stroke concluded that Embedded Motor Imagery is useful in Rehabilitation approach for adult stroke[63]. Similarly, the post test scores of Dynamic Gait Index, Berg Balance Scale and Kinesthetic and Visual Imagery Questionnaire score was higher than the pre test values while comparing both and it was significant at p<0.05 level in Group B using Added motor imagery training. This study is in line with the study of Abeer A. El-Wishy, et al (2013) who added the motor imagery training to the physical therapy program on Gait concluded that the that locomotor imagery training sessions when added to physical therapy program improved gait functions in Parkinson's patients[18]. The results of this study are in line with the study of Schuster et al (2012) who compared the Added and Embedded Motor Imagery training in chronic stroke patients. Both approaches were compared when learning a complex Motor Task (MT): 'Going down, laying on the floor, and getting up again. They suggested that the Motor Task 'Going down, laying on the floor, and getting up again', consisting of seven stages, should be included in physiotherapy sessions and practiced with all patients during every stage of the rehabilitation process on a regular basis[1]. Both Motor Imagery (Embedded Motor Imagery and Added Motor Imagery) interventions were designed based on the accepted Motor Imagery intervention paradigms. Embedded Motor Imagery is based on the work from Liu et al[30,32] and Added Motor Imagery training is based on the work from Page et al[28,31,67]. Ravey has drawn a distinction between the process of imaging a movement once or few times (i.e Motor Imagery) and the act of repeating the imagined movements several times with intention of learning a new ability or perfecting a new skill (i.e mental practice). Thus, Motor Imagery will refer to a specific cognitive operation, whereas, mental practice will designate a training method that can use various cognitive process including Motor Imagery[64]. This study revealed insignificance between the Embedded and Added group because of small sample size and short duration of the study. There was difficulty in scoring the Kinesthetic and Visual Imagery Questionnaire during the pre-assessment. In general, the scoring of Kinesthetic Imagery Questionnaire was less compared with Visual Imagery Questionnaire. Both Motor Imagery approaches were used to improve the level of imagination in both the groups and the scoring of Kinesthetic and Visual Imagery Questionnaire were increased in both groups whereas, some people showed same scoring of visual and kinesthetic scoring. Driskell et al. (1994) suggested that it is important to maintain subjects' motivation for a positive for overall effect of Motor Imagery[35,1]. In this study, some subjects mentioned that listening to the same tape became less interesting after 2-3 times. On the other hand, subjects in Embedded Motor Imagery group mentioned the difficulty to capture all details and motor task order to imagine during the first two sessions. Both occurrences showed that duration and content play an important role to learn and further use Motor Imagery independently. Thus, Embedded Motor Imagery and Added Motor Imagery training approaches are equally effective in improving Balance and Gait in subjects with stroke (relative recovery stage) and can be used as a part of stroke Rehabilitation. This study experience suggests that, for subjects who find the actual practice of tasks too demanding, such as those with poor mobility functioning and a low energy level, mentally rehearsing the performance can serve as a supplement to performing the task during the training. This would further increase the effectiveness of the training program and, more important, the generalization of the learned skills, which is essential for adapting to community living after a stroke[30].

## CONCLUSION

Adding 2 weeks program of Embedded and Added Motor Imagery training combined with physiotherapy are equally effective to improving balance, gait and imaginary ability of individuals with stroke. Therefore adding motor imagery training to conventional therapy is recommended for individuals with stroke to learn motor task. It is suggested a similar study with a larger number of participants with control group with shorter components of task. EEG studies can be done to confirm whether the subject was imagining the given task.

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