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MOTOR IMAGERY IN GAIT & BALANCE REHABILITATION FOR POST STROKE HEMIPARESIS

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ABSTRACT

Background: There is dearth of literature elucidating application of intensive motor imagery on gait and balance rehabilitation in post stroke hemiparesis although sufficient literature is available on efficacy of motor imagery in upper limb function following stroke and in the field of sports and psychology.

Methods: 30 stroke patients from hospitals in Delhi were screened on the basis of an assessment performa. The subjects were included in the study after getting the informed consent. Selection of subjects was done according to sample of convenience. Allocation of subjects into two groups, 15 each, following inclusion criteria was done according to permuted block randomization. It was a three week study, every week a video was shown to the experimental group, to imagine and feel normal movements of paretic limbs, while conventional therapeutic exercises remained same for control and experimental group.

Results: Comparison was done between the groups of age, weight and height before intervention. MMSE, MAS, KVIQ were compared between the groups before intervention. Post interventions, weekly walking speed was compared both within and between groups using ANOVA and independent t-tests respectively. Similarly, TPOMA balance scores and gait scores were assessed both within and between groups, weekly, using ANOVA and Mann Whitney U test respectively.

Conclusion: Motor Imagery facilitates faster recovery and complements conventional physical therapy. It has proved beneficial in enhancing locomotors capabilities of stroke patients. Balance and walking speed has shown statistically significant improvement, due to motor imagery along with conventional exercises. Gait did not show statistically significant improvement even though the scores were higher for the MI+PT group than PT group alone.

KEYWORDS : Motor imagery, gait, stroke

INTRODUCTION

Stroke results in central nervous system damage. Abnormalities of motor behavior, following central nervous system damage are traditionally divided into positive and negative symptoms. This classification is based on hierarchical model of motor control theory in which central nervous system damage is believed to result in release of more primitive or automatic behaviors from higher control (Craik, 1991). Positive symptoms includes abnormal postures; exaggerated proprioceptive reflexes producing spasticity and exaggerated cutaneous reflexes of the limbs producing flexion withdrawal spasms, extensor spasms and Babinski response (Craik, 1991,p.156). Negative symptoms include cerebral and spinal shock, weakness, loss of dexterity (Burke 1988)[1]

Stroke is the major cause of postural imbalance in terms of static (e.g. weight distribution, pressure distribution) and dynamic (e.g. equilibrium reaction, weight shifting control). Ability to initiate and control weight shift towards either leg is a prerequisite for independent walking, leading to load and unload the affected leg while standing is an important step in the balance and gait training of stroke patients[2].

Stroke imposes a substantial economic burden on individuals and society. Lifetime cost per person per stroke occurring in 1990 is estimated to be $228,030 for SAH, $123,565 for ICH, $90,981 for ISC and $103,576 averaged across all strokes subtypes. Indirect costs accounted for 58% of lifetime cost. Acute care cost incurred in the 2 years following first stroke accounted for 45%, long term ambulatory care accounted for 35%, and nursing home costs accounted for 17.5% of aggregate lifetime costs of stroke[3].

Motor Imagery is the mental representation of movement without any body movement[4]. White and Hardy proposed that imagery is an experience that mimics real experience. We can be aware of seeing an image, feeling movements as an image or experiencing an image of smell, tastes or sounds without actually experiencing the real thing[5]. Recent research demonstrates that motor imagery and similar processes such as observing a demonstration or watching a video, produce a selective enhancement of neural activity in motor pathways concerned with the simulated action[6].

The ability to apply motor imagery as well as the contribution of motor imagery practice to rehabilitation has been established for individuals with acute, chronic, mild and severe hemi paresis[7,8,9].

Page and colleagues[10,11] demonstrated the advantage of motor imagery practice in one case report and two small RCTs .In most recent RCT ,the eleven individuals in the chronic phase after stroke who mentally rehearsed ADL significantly improved compared with those who mentally rehearsed ADL significantly improved compared with those who only had physical practice[10,11,12]

In a case study by Dickstein and Colleagues[13], gait was trained using a home based motor imagery practice programme. Participants who had stroke were trained for 15 mins, 3 times a week, for 6 weeks using both visual and kinesthetic imagery. The limitation cited in this case study for improving gait using motor imagery was that the patient's imagery was focused on asymmetrical gait pattern throughout mental practice, as he acknowledged being unable to imagine his own walking in symmetrical fashion. Alleviation of this specific disorder demands motor imagery for normal movements and symmetrical gait which can be accomplished by showing a video of normal movements and gait to the patient at the onset of each session. Hence the study aims at incorporating motor imagery to train balance and gait in hemi paretic population after stroke in 30 subjects and study its effect in balance, gait and walking.

METHODOLOGY:

The study was an experimental design, consisting of two groups, namely experimental group(group A) and conventional group (group B).Both groups of stroke patients received conventional physical therapy for improving balance and gait. Experimental group practiced motor imagery apart from physiotherapy.

Thirty stroke patients from hospitals were screened on the basis of an assessment performa. The subjects were included in the study after getting the informed consent. Selection of subjects was done according to sample of convenience. Allocation of subjects into two groups, 15 each, was done according to permuted block randomization.

Criteria for selection of subjects were:
Inclusion criteria

- Diagnosed as having had a first unilateral cerebral infarction as

confirmed by MRI
- Sub acute phase(1 month to 1 year post stroke)
- Age between 40-70 yrs
- Both males and females
- Right and left both sides will be included
- Mini mental status examination score should be more than 24; no severe cognitive impairment
- An average score of less than 3 on the vividness of movement imagery questionnaire.
- Affected upper limb and lower limb tone<2 on modified ashworths scale
- Ability to walk with or without assistance.
- Independent in performing daily activities
- Having given their voluntary consent.

Exclusion criteria
- Medically unstable
- Hemorrhagic lesions
- Lesions affecting both hemispheres as determined by MRI available in medical records.
- Unilateral neglect
- Visual and hearing impairment
- Significant sensory and communication deficits
- Excessive pain in the affected upper and lower limb as measured by a score of more than or equal to 4 on a 10 point visual analogue scale.
- Musculoskeletal injuries to upper extremity & lower limb; fractures and dislocations
- Unmanaged seizures
- Any other neurological disorder
- Alcohol dependence

Equipments used were - stop watch, measuring tape, standard chair, armless chair, chalk, high chair, low chair, Bed/couch, medium sized ball, balance /wobble board, football, staircase/steps, display unit to run the videos, 3 CDs (one for each week).

Space and Facilities included VIMHANS, Nehru Nagar, New Delhi, Maharaja Agrasen hospital, Pashchim Vihar, New Delhi.

All subjects were informed about the type of training to be given and the benefits of the training programme. The subjects of both the groups were explained about the daily regimen of exercises, which is a compendium of gait and balance exercises. The study incorporated 3 weeks protocol for both the groups' altogether. Every week they were given treatment for 4 days. Five different tasks were introduced each week. These activities progressed depending upon their difficulty level each week.

Group A: Each patient in experimental group was shown a video comprising of normal movements of the five tasks selected for the week, wherein each task was repeated three times. After seeing the video, patient performed each activity physically for ten repetitions. Subjects were asked to close their eyes and imagine they were performing the physically practiced task, similar to one shown in the video; subjects were urged to imagine themselves from a first person perspective, to feel their trunk, legs, hands and feet to concentrate on their movements. Sequence of the task was verbally explained to the patient for better recalling of sensations in muscles during the movements. During the entire exercise schedule subject's attention was focused on the position, and movement of their body, on proprioceptive inputs coming from the leg muscles (quadriceps and adductors) and on the tactile sensations of foot floor contact. Thereafter the patient was asked to narrate the sequence of tasks, rehearsed mentally, by the patient. The same steps were followed for the remaining four tasks. At the end subjects were asked to relax.

Group B: Patients in control group physically performed each of the five tasks in a week, ten times and followed the same routine for successive weeks.

5 Tasks for first week include:
- Sitting at the table and reaching in different directions for objects located beyond arm's length to promote loading of the affected leg and activation of affected leg muscles.
- Chair rises: repeated rising from a seated position, progressing from using arms to not using arms and from high surface to lower
- Toe rises: repeated rising up on toes, progressing from upper extremity support to no support and from bilateral rises to unilateral rises on affected lower extremity only.
- Heel rises in standing to strengthen the affected plantar flexor muscles.
- Standing up from chair walking a short distance and returning o the chair to promote a smooth transition between the two tasks.

5 Tasks for second week:
- Standing with BOS constrained, with feet in parallel and tandem conditions reaching for objects, including down to the floor, to improving standing balance.
- Partial squats: progressed by increasing movement magnitude.
- Wall exercises: repetitions of standing from a wall and falling backwards with the trunk straight to contact the wall with the upper back and bouncing upright again, progressing to greater distances from wall.
- Standing on balance disk.
- Sudden stops and turns during walking.

5 Tasks for third week:
- Step ups: repeated stepping anteriorly and laterally onto a step: up with affected leg and down with unaffected leg, progressing to higher step and decreasing upper extremity support.
- Kicking a ball with either foot.
- Marching: Repeated marching in place, progressing from upper extremity support to no support.
- Unilateral standing with 90 degree knee flexion with both lower extremities one after the other.
- Walking over stairs will provide the opportunity for practice of walking under variant conditions.

For outcome variables, scales used were:
- Tinetti Performance Oriented Mobility Assessment (balance and gait tests)
- 10 meter walk test
- KVIQ-For vividness of imagery assessment, kinesthetic and visual imagery questionnaire was used

Patients were demonstrated movements and immediately following observation, they were requested to, close their eyes and attempt to imagine and feel what they had seen, then rate the clearness of image seen in the mind's eye. The rating was made by promptly marking on a scale ranging in visual and kinesthetic aspect of movements from 1 (no image; no sensation) through 5 (image as clear as seeing; as intense as executing the action).

RESULTS
The analysis was done by using SPSS statistical software having 15.0 versions. The between group comparison was done by using Mann Whitney U test and unrelated t-test was used for comparing walking speed between the groups. The within group factor was intervention which was measured at 4 levels i.e. pre intervention and post intervention after each week, successively for three weeks, on day 1,7,14 and 21 for all dependent variables i.e. gait, balance and walking speed. TPOMA scores were analyzed using friedman test and walking speed within group was analyzed using ANOVA. Tinetti performance oriented mobility scale is an ordinal scale and walking speed is interval ratio scale hence the tests were used. Baseline measures for both groups like age, weight and height were analyzed using unpaired t test MAS scores, MMSE scores and KVIQ scores were analyzed using Mann Whitney U test. The level of significance used to analyze the results was fixed at p<_0.05

Table 1: Comparison of age, weight and height between the groups before intervention

	Experimental group A Mean ±SD	Conventional group B Mean ±SD	t	p
Age	58.200±6.930	58.466±6.379	0.110	0.456
Weight	69.266±9.090	69.200±5.697	0.024	0.490
Height	165.800±7.532	166.733±7.085	0.350	0.364

Table 2: Comparison of MMSE, MAS and KVIQ between the groups before intervention.

	Experimental group A Mean ±SD	Conventional group B Mean ±SD	U	P
MMSE	26.666±2.126	26.800±2.305	0.168	0.433
MAS	0.666±0.487	0.666±0.487	0.000*	0.5
KVIQ	45.533±5.986	45.266±5.921	0.066	0.473

*= significant at ≤0.05

MMSE = mini mental status examination
MAS = modified ashworths scale
KVIQ = kinesthetic and visual imagery questionnaire

Table 3: Comparison of walking speed between the groups and within the groups.

Walking speed		Group A Mean±SD N=15	Group B Mean±SD N=15	BETWEEN GROUP ANALYSIS Independent t-test	
				t	p
Pre 1		0.2933±0.1951	0.1800±0.1200	1.916	0.033*
Post1		0.3347±0.2192	0.2093±0.1565	1.802	0.041*
Post2		0.4127±0.1938	0.2473±0.1657	2.511	0.009*
Post 3		0.5007±0.2022	0.2607±0.1720	3.501	0.001*
ANOVA	F	43.927	18.221		
	P	0.000*	0.001*		
Within group analysis	Pre 1 Vs Post1	.001*	.070*		
	Pre 1 Vs Post2	.000*	.003*		
	Pre 1 Vs Post3	.000*	.001*		
	Post 1 Vs post2	.000*	.040*		
	Post 1 Vs Post3	.000*	.004*		
	Post 2 Vs Post 3	.005*	.008*		

*=significant at ≤ 0.05

Table 4: Comparison of TPOMA balance scores between the groups and within the groups.

TPOMA Balance scores		Group A Mean ±SD N=15	Group A Median	Group B Mean ±SD N=15	Group B Median	BETWEEN GROUP ANALYSIS Mann Whitney U Test		
						Z	U	P
Pre1		8.200±5.267	12.000	5.333±2.943	4.000	1.299	81.500	0.097
Post 1		11.133±4.501	13.000	8.133±2.263	8.000	2.195	60.000	0.014*
Post 2		13.666±3.154	16.000	10.133±2.231	10.000	3.024	41.000	0.001*
Post3		14.866±2.166	16.000	13.200±2.007	14.000	3.023	41.500	0.001*
Within group analysis (Friedman test)	Chi2	39.609		43.375				
	P	0.000*		0.000*				

*=Significant at ≤ 0.05

Table 5: Comparison of TPOMA gait scores between the groups and within the groups.

TPOMA gait scores		Group A Mean± SD N=15	Group A Median	Group B Mean± SD N=15	Group B Median	BETWEEN GROUP ANALYSIS Mann Whitney U Test		
						Z	U	P
Pre 1		7.600±4.322	11.000	6.133±2.294	6.000	1.143	85.500	0.126
Post 1		8.200±4.109	11.000	7.333±2.380	8.000	1.203	84.000	0.114
Post2		9.666±2.497	11.000	9.200±1.897	9.000	0.656	97.000	.256
Post 3		10.266±1.907	11.000	9.533±1.552	9.000	1.388	80.000	0.082
Within group analysis (Friedman test)	Chi2	27.659		38.016				
	P	0.000*		0.000*				

DISCUSSION

So much information can be gleaned from the history that no amount of trouble should be spared to obtain the fullest details. Literature is replete with contribution of motor imagery to acquiring and improving the motor skills of people with hemiparetic stroke [4,8,10,12,14,15,16,17,18,19.] This study examined the relative effectiveness of physiotherapy alone versus physiotherapy plus mental practice training for people with hemi paresis in improving their gait and balance potential.

If we consider, between group analysis of TPOMA balance scores, it is clearly indicated that post test values for MI group are statistically significant than the insignificant pre test values of both groups .So our research hypothesis can be accepted in implementing MI as a valid tool for improving balance in post stroke hemiparetic population. This may add to the insufficient literature that is posing a hindrance in application of MI in improving balance performance of stroke patients.

Although this achievement is bound to have a positive effect on gait as well, yet our results are not assertively supporting the view of the previous case studies too, as there is no statistically significant difference with respect to gait between the groups, though the mean scores for gait are higher in MI group.

When we talk about walking speed there is significant difference between groups A and B at both pre and post test levels. Likewise, between group analysis of TPOMA gait scores, at both, pre and post test levels, shows no statistically significant difference, so we cannot assume any positive effect of MI on gait potential of stroke patients considering, these two similarities at pre and post test levels, between groups A and B.

Our data suggests similarity between both the groups before starting the intervention with respect to age, weight, height, MMSE, MAS and KVIQ scores of all patients but a chance factor is revealed, that is the pre test values for walking speed should have been included as a criteria for selection of subjects initially before assigning the groups. This could have ameliorated the difference in pre test values between the groups for walking speed. So even though walking speed has shown statistically significant improvement in MI group we cannot hold MI solely responsible for this improvement because of difference in pre test values. In future this aspect shall be taken into consideration.

Our data suggests that within group A or in experimental group, significant difference emerged in walking speed and balance after intervention. Improvement was more in second and third weeks of intervention as compared to the first week. Gait observations also showed significant improvements within group A. In gait early intervention results were found to be more significant i.e. after first week of exercise program. However after second and third weeks relatively the improvement seen in gait was not statistically significant. Balance showed statistically significant improvement after each week of exercise regime. Similarly within group B or conventional group, walking speed, balance and gait showed significant improvements.

In group A mean % change in walking speed after first week from baseline was 16.098.After second week from baseline 57.1707 and after third week from baseline it was 100.768. Mean % change in balance score after one week from baseline was found to be 84.765, after two week from baseline 183.953 and after three weeks from baseline it was 241.453. Gait showed mean % change after first week from baseline as 15.151, after two weeks from baseline 74.141 and after three weeks from baseline it was 97.474.

In group B mean % change in walking speed after first week from baseline was 44.093, after second week from baseline it was found to be 89.606 and after third week from baseline it was 151.053. Gait after first week from baseline showed mean % change as 22.486, after second week from baseline it was 66.825 and after third week from baseline it was 76.825.

Our results are fully consistent with the hypothesis that stroke patients participating in a 3 week regime of physiotherapy with mental practice can improve walking speed significantly [13, 19,20] also the data is in accord with previous experiments on effects of mental practice on balance in elderly women [21] and walking balance in elderly population [22].

Results obtained with imaginary foot tapping demonstrated that the number of foot movements in the imagined and the executed conditions correlated with the increase in time intervals indicating that the patient made fewer taps during the imagined condition [17], this finding is in line with recent reports where patients with stroke and mild traumatic brain injury demonstrated a bilateral slowing of movements in imagined conditions[23,24]. This bilateral slowing of mentally imagined movement was associated with impaired working memory, suggesting a disturbance of the motor imagery process[23,24,25]

It has been pointed out by researchers that efficacy of mental practice becomes apparent when carrying it out for more than 5 times[26].

In our study, each task was mentally rehearsed 10 times after its physical execution for the same number of times[27] thereby giving ample time and practice for cortical activation to take place inspite of slow imagery ability after CVA.

A plausible alternative mechanism for the effect observed could be natural motor recovery example (exonal sprouting)[7]. In few patients existence of a stable motor deficit was conformed by their former therapist. The short duration of the treatment and the rapid improvement in experimental group compared with patients in conventional group also make natural recovery less probable. It could also be argued that the effect observed was participation in therapy. Although this argument cannot be completely dismissed, data obtained from our comparison conventional group, who showed little response to the therapy administered, further suggests that attributes to imagery treatment.

We included patients post stroke one month to one year, similar to previous randomized controlled series[7, 28] where 13 consecutively admitted patients between 4 weeks and 1 year post stroke exhibiting stable motor deficits in their affected upper limb, were included and imagery complemented to the therapy in improving outcome more than therapy alone.

Our results are in favor of the view that optimum duration of motor imagery practice should be 3 weeks in stroke patients. After 3 weeks motor imagery practice scores are higher for all dependant variables in experimental group as compared to conventional group[14, 15, 29] practicing only physically. However in a recent study, functional MRI changes in brain have been shown even after 1 weeks motor imagery practice in locomotor activity[30], but it was carried on normal subjects.

Motor imagery skill has the advantage in maintaining the training effect after visual feedback has been removed[18, 31].Our findings are in line with previous study showing enhanced positive effect of visual feedback together with mental practice on improving and maintaining a symmetrical stance posture in people with hemi paretic stroke than is seen with visual feedback approach alone but there is evidence that says visual feedback approach alone [31] but there is evidence that says visual feedback or conventional balance training in addition to regular therapy affords no added benefit when offered in the early stages of rehabilitation following stroke[32].

Gait rehabilitation literature suggests 3 times in 4 weeks to 8 weeks training optimum for positive outcomes[13].This implies minimum 12 sessions are needed (3 times in 4 weeks) for gait training. In this study, duration of training is 4 times in 3 weeks which is in line with the evidence hence improvement is seen in both the groups though scores are higher in experimental group.

In this study 15 tasks were incorporated over a period of 3 weeks [33,34]. 5 tasks every week were practiced, starting from simpler to complex activities. It not only helped patients to remain interested and motivated during the course of the training rather enabled them at the end to accomplish difficult activities [14,15].

Focused attention is one of the factors influencing imagery ability of a person and this is more threatened after a cerebrovascular accident. To overcome this possibility, patients in mental practice group viewed a video showing three repetitions of each of the five tasks allocated to each week. These were performed by a normal individual thereby ameliorating any chance of imagining their abnormal movement patterns which might not bring positive clinical outcomes, as have been experienced earlier [13].This was done in order to give a visual representation to the patient about the talk to be mentally practiced. Patient was then asked to visualize the task and explain the sequence. He was asked to visualize the task and explain the sequence. He was asked to physically practice the task for ten repetitions followed by 10 repetitions of mental practice [8]. Studies have shown that intensive repetitive practice render more positive outcomes for upper limb rehabilitation [8] for gait, balance and mobility for individuals with chronic stroke [33,34] as well as sub acute stroke patients compared to conventional PT alone [28].

Several theories can be found in the literature to support the use of mental practice in improving motor skills. Symbolic learning theory [8,35] which proposes that mental practice facilitates motor performance by allowing the individual to rehearse the cognitive components of a task [24,25,26] Fits well with current rehabilitation literature in stroke patients. This has been explained by the fact that mental practice activates areas of the cortex similar to those activated by physical practice [8,11,36,37,38,39,40,41]. Other theories that have been put forward are psycho neuromuscular theory [8,42]. This theory centers on the idea that brain has motor memories which consists of motor programs or schemas that are established when a skill is repetitively practiced. Psycho neuromuscular theory states that mental rehearsal duplicates the actual motor schema being rehearsed.

At the start of the intervention phase each mental practice plus physical therapy session lasted for about one hour and by the end of this phase this has reduced to an average of 45 minutes.Each person became more accustomed to,and skilled at using the technique and this had an effect on how much instruction he or she required and the length of time they needed to complete the session.

Improvement in standing balance control is more important than improvement in leg strength or synergism to achieve improvement in walking ability [43], where as reduction in visuospatial attention is independently related to improvement of gait. Finally, time itself is an independent covariate that is negatively associated with change on functional ambulation categories (FAC),suggesting that most pronounced improvements occur earlier after stroke [43].Our results too favor this view, since gait showed significant improvement after first week of treatment but eventually the performance was not statistically significant.

A hierarchical model of organization of action implies that the short term memory is a storage or copy of various representational steps. These memories are erased when an action corresponding to the represented goal takes place. In contrast if th action is incompletely or not executed, the whole system remains activated and the content of the representation is rehearsed. This mechanism would be the substrate for conscious access to this content during motor imagery and mental training [44].

Our results follow the consensus that ability to imagine movements improved in the timeframes proportional to the speeds at which they were depicted in the movies [19]. A linear trend is seen in imagined movement time and walking speeds in 3 week intervention.

Live instruction is better than the audio taped instruction [15, 18]. This was followed in one study to get better outcome. Although many studies have shown use of audio tapes to be successful [7,9,10] yet some have shown no significant results after use of audio tapes or directed instruction of mental practice [45]. However a task with specific detailed instruction is more appropriate than abstract one [18]. In another study it was found that no significant difference exists between the live instruction group and the group that received videotaped instructions. However live and videotaped modeling are more effective than a hand out or script alone for achieving performance accuracy of basic exercise program, as measured by immediate and delayed retention tests [46].

A survey indicated that dynamic group was more motivated to perform the exercises in a home environment and more confident about performing the exercises correctly. Additionally it has been reported that subjects prefer using video tapes over illustrations to learn the exercises. Findings suggest, dynamic modeling via video tape is more effective than static illustrations for promoting correct form for the exercises. Moreover, video tape is indicated to be more appropriate for encouraging confidence and motivation in an un-supervised exercise environment such as home exercise program [47].

CONCLUSION

Motor imagery facilitates faster recovery and compliments convention physical therapy. It has proved beneficial in enhancing locomotors capabilities of stroke patients. Balance and walking speed has shown statistically significant improvement, due to motor imagery along with conventional exercises. Gait did not show statistically significant improvement even though the scores were higher for MI + PT group than PT group alone.

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