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Effectiveness of Brain Gymnasium for Motor and Cognitive Impairments through the Unaffected Hemisphere in Post-Stroke Individuals

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ABSTRACT

Background: Stroke, a leading cause of death and disability in India, often results in cognitive and motor impairments due to disrupted blood flow to the brain. The most common type, ischemic stroke, deprives the brain of oxygen and nutrients, leading to various neurological deficits. Recovery heavily depends on neuroplasticity, where the brain reorganizes itself to compensate for damaged areas, with both the affected and unaffected hemispheres playing a role in motor and cognitive recovery. The unaffected hemisphere plays a crucial role in compensating for lost functions, aiding in the re-establishment of motor control and coordination during stroke recovery. Brain Gym, an intervention based on kinesiology, uses targeted exercises to stimulate cognitive and motor functions, including activities like puzzle solving and sensory stimulation, to support rehabilitation in stroke survivors.

Method: An interventional study was conducted at Krishna Vishwavidyapeeth, following institutional review board and ethics committee approval, to assess the effectiveness of brain gymnasium techniques in improving motor and cognitive impairments in post-stroke individuals through the unaffected hemisphere. The study involved 30 participants selected based on inclusion and exclusion criteria, with a 3-week program conducted six times a week. The primary goal was to evaluate the efficacy of this intervention in enhancing motor and cognitive skills, contributing to evidence-based practices in neurological rehabilitation.

Result: The brain gymnasium intervention significantly improved both cognitive and physical functions in post-stroke individuals. MoCA scores increased from 13.1 (SD = 2.280) to 21.9 (SD = 2.076) with a P-value < 0.0001. Motor function (Fugl Meyer) improved from 34.7 (SD = 3.261) to 58.6 (SD = 4.054), joint ROM increased from 13.2 (SD = 2.524) to 19.6 (SD = 1.905), sensation improved from 5.4 (SD = 1.102) to 10.0 (SD = 1.438), and joint pain reduced from 11.8 (SD = 2.069) to 19.2 (SD = 2.212), all with P-values < 0.0001, highlighting the intervention's effectiveness in enhancing cognitive and physical recovery.

Conclusion: In conclusion, the brain gym program targeting the unaffected hemisphere significantly improved cognitive and motor functions in stroke patients. Using sensory stimulation, bilateral exercises, and therapies like mirror box therapy and PNF, participants showed notable gains in motor skills, joint ROM, sensation, and cognition, highlighting its effectiveness in enhancing neuroplasticity and recovery.

Keywords: *Brain Gymnasium, Unaffected Hemisphere, Motor and Cognitive Impairements, Post- Stroke individuals.*

1. INTRODUCTION

Strokes are becoming more common in India, where they are the fourth major cause of mortality and the fifth leading cause of disability. [1]. A stroke, also known as a cerebrovascular accident (CVA), is a sudden loss of neurological function caused by a disruption in blood flow to the brain. Ischaemic stroke is the most frequent kind, accounting for around 80% of all stroke victims. It occurs when a clot obstructs or inhibits blood flow, depriving the brain of essential oxygen and nutrients. A hemorrhagic stroke happens when blood arteries break and allow blood to enter or surround the brain. Clinically, a wide range of focal abnormalities are possible, including changes in consciousness and impairments in sensory, motor, cognitive, perceptual, and language capacities. [2]. In this article, we will focus on cognitive and motor impairments experienced by patients after stroke.

Cognition is the process of learning knowledge and understanding via cognition, experience, and the senses. Cognitive ability domains can be categorized in several ways. One approach is to classify them based on processes like memory, attention, language, or executive functioning. Another method focuses on regional brain functions derived from lesion studies, associating tasks with brain structures such as the frontal or temporal lobes. A hierarchical organization also distinguishes between top-down and bottom-up processes, where basic sensory tasks are less complex compared to reasoning and problem-solving, which are considered executive functions. These tasks often require the integration of multiple functions, while simpler sensory tasks involve minimal higher-level processing [3]. Cognitive impairment after a stroke is commonly observed in many patients [4]. Motor control is the process of starting, directing, and grading deliberate voluntary movement [5]. Both fine motor skills and gross motor skills can be significantly affected, depending on the level and extent of the lesion.

A crucial aspect of post-stroke recovery is the brain's ability to reorganize itself through a process known as neuroplasticity. Plasticity is the ability of any structure that is weak enough to change due to an external stimulus but strong enough not to be molded completely at once. [6]. Neuroplasticity, also known as brain plasticity, is the nervous system's ability to change activity in response to internal or external stimuli by modifying its structure, functions, and connections. Neurons have the potential to change the intensity and effectiveness of synaptic transmission through activity-dependent mechanisms, which is known as synaptic plasticity. [7].

The corpus callosum, a thick band of nerve fibers connecting the brain's two hemispheres, is made up of approximately 200 million axons. Because of this structure, information processed in one side of the brain can be shared with the other, facilitating communication between the two hemispheres. Research indicates that the neural substrates in the unaffected hemisphere can facilitate recovery only when the substrates in the affected hemisphere are significantly damaged [8]. The primary motor area (M1) is essential for upper-limb recovery and is frequently targeted in stroke therapies. The premotor cortex (PMC) and supplementary motor area (SMA) are closely associated to M1 and are essential for motor activity.

A recent stroke study revealed that the strength of the ipsilateral M1 connection could be key in assessing and predicting motor performance in stroke survivors [9]. The study found a strong association between the connectivity strength between the affected hemisphere and the opposite M1 and improved functional abilities. This suggests that the brain's ability to form compensatory connections in the ipsilateral M1 plays a crucial role in motor recovery, aiding in rehabilitation efforts [10].By understanding these connections, clinicians could better predict recovery and design more personalized rehabilitation strategies to enhance motor function in stroke survivors [11]. Behavioral recovery following a stroke is largely dependent on the sensorimotor network in the affected hemisphere of the brain [12]. This network is critical for restoring motor control and sensory abilities, which are frequently damaged following a stroke. [13] .The ability of the brain to reorganize and strengthen these sensorimotor pathways, especially in the damaged hemisphere, is vital for functional recovery [14]. Enhanced connectivity and activation within this network can significantly improve motor skills, coordination, and overall behavioral outcomes, supporting the rehabilitation process for stroke survivors [15]. The sensorimotor network strongly influences behavioral recovery after a stroke in the affected hemisphere, but the unaffected hemisphere also plays a critical role in motor recovery. Following a stroke, the brain can exhibit plasticity, where the unaffected hemisphere helps compensate for the lost functions of the damaged side [16]. The unaffected hemisphere can take over certain motor and sensory activities, helping to recover motor control and coordination [17] . Together, the affected and unaffected hemispheres form a dynamic network, with both hemispheres contributing to the rehabilitation process and enhancing motor recovery through neural reorganization and functional compensation [18].

Brain Gym is an academic program based on kinesiology. It involves a series of specific movement patterns that engage the head, eyes, and limbs, focusing on three key dimensions: laterality, attention, and centering. During a typical Brain Gym session, participants take part in a diverse range of activities that stimulate various aspects of cognitive and physical functioning [19]. In this study, several exercises were done in the brain gymnasium using PNF (Proprioceptive Neuromuscular Facilitation) techniques as well as sensory stimulation bilaterally and concurrently.

2. MATERIALS AND METHOD

- Following institutional review board and ethics committee approval, an interventional study was undertaken at Krishna Vishwavidyapeeth to investigate the effectiveness of brain gymnasium for motor and cognitive impairment through the unaffected hemisphere in post-stroke individuals. The major goal of this study was to determine the efficacy of this intervention in improving motor and cognitive skills in post-stroke patients, guiding evidence-based treatment in neurological rehabilitation. There were 30 sample sizes taken. Participants were selected according to inclusion and exclusion criteria. This was a 3-week program which was performed 6 times a week.

Participants –

1. A total of 30 post-stroke survivors were recruited for this study. Participants were selected based on stringent

inclusion criteria: (1) Adults aged 30-60, (2) Unilateral Stroke Survivors, (3) Mild to Moderate Cognitive Impairements, (4) Mild to Moderate Motor Impairements, (5) Stroke Survivors (1 to 5 years post-stroke), (6) Hemiparesis, (7) Mild Hemiplegia, (8) Able to participate in physical therapy. Exclusion criteria: (1) Severe Cognitive Impairment, (2) Severe Motor Impairments, (3) Severe Comorbidities, (4) Recent stroke survivors, (5) Severe Hemiplegia, (6) Current Participation in Another Rehabilitation Trial.

The experimental intervention consisted of a structured exercise program, comprising six sessions per week for a duration of three weeks, with each session lasting approximately 45-50 minutes, totaling 18 sessions per participant.

Procedure –

All patients provided informed verbal consent after receiving a comprehensive explanation of the study protocol. The interventional study only targets the upper limb of the patient.

Treatment Protocol -

PHASE 1 - PREPARATORY PHASE

- Breathing Exercises – Patient performs pursed lip breathing with eyes closed. (60 seconds)
- Followed by 5 deep breaths.

PHASE 2 – ACTIVITY PHASE

- Key points for Phase 2: -
- The table outlines activities that must be done bilaterally and simultaneously (e.g., Point 1)
- The therapist should provide auditory biofeedback during exercises.
- The patient should use a mirror for visual biofeedback of their movements.
- Follow the sequence of exercises as indicated in the table.
- For performing 5th Exercise –

<u>Setup</u>: The patient sits comfortably with the affected limb hidden in a box and the unaffected limb visible. A mirror reflects the movements of the unaffected limb, obscuring the affected limb from sight.

<u>Movement Observation</u>: The patient moves the unaffected limb while observing its reflection, creating the illusion of movement in the affected limb.

<u>Motor Imagery</u>: The patient is encouraged to mimic the unaffected hand's movements with the affected hand to facilitate motor recovery through enhanced motor imagery.

- Before starting any Mirror Box exercise first stimulation is given to the affected hand while the unaffected arm performs the exercise.

Affected Upper Limb	**Unaffected Upper Limb**
1. <u>Sensory Stimulation-</u> - Texture Stimulation (Soft to Rough) - Cold Stimulation (Ice pack) Each for 1 Minute from distal to proximal.	1. <u>Performing PNF exercises.</u> - The first diagonal (D1): Flexion-adduction-external rotation pattern of the gleno-humeral joint and Extension-abduction-internal rotation pattern of the gleno-humeral joint. (10 Repetitions) - The second diagonal (D2): Flexion-abduction-external rotation pattern of the glenohumeral joint and Extension-adduction- internal rotation pattern of the glenohumeral joint. (10 Repetitions)
2. <u>Performing PNF exercises.</u> - The first diagonal (D1): Flexion-adduction-external rotation pattern of the gleno-humeral joint and Extension-abduction-internal rotation	2. No Activity performed.

pattern of the gleno-humeral joint. (10 Repetitions) - The second diagonal (D2): Flexion-abduction-external rotation pattern of the glenohumeral joint and Extension-adduction- internal rotation pattern of the glenohumeral joint. (10 Repetitions)	
3 . Sensory Stimulation- - Texture Stimulation (Soft to Rough) - Cold Stimulation (Ice pack) Each for 1 Minute from distal to proximal.	3. Strength Training – - Theraband Exercises of Shoulder, Elbow, Wrist and Fingers.
4. Strength Training – - Theraband Exercises of the Shoulder, Elbow, Wrist and Fingers	4. No Activity Performed.
5. Sensory Stimulation- - Texture Stimulation (Soft to Rough) - Cold Stimulation (Ice pack) (Note – Before starting the exercise stimulation is given inside the box)	5. Hand Exercise for improving Cognitive and Motor skills. - Make Fist. - Stretch the hand. - Curl your finger. - Pinch the Book. - The patient tightly grips the pen, glass, and ball one at a time while the therapist gently pulls them away. (10 repetitions each)
6. Hand Exercise for improving Cognitive and Motor skills. - Make Fist. - Stretch the hand. - Curl your finger. - Pinch the Book. - The patient tightly grips the pen, glass, and ball one at a time while the therapist gently pulls them away.	6. Hand Exercise for improving Cognitive and Motor skills. - Make Fist. - Stretch the hand. - Curl your finger. - Pinch the Book. - The patient tightly grips the pen, glass, and ball one at a time while the therapist gently pulls them away.
7. Sensory Stimulation- - Texture Stimulation (Soft to Rough) - Cold Stimulation (Ice pack)	7. Peg Board Activity- - Arranging Shapes. - Tracing the shapes through the gripper. (1 repetition each)
8. Peg Board Activity- - Arranging Shapes. - Tracing the shapes through the gripper. (1 repetition each)	8, Peg Board Activity- - Arranging Shapes. - Tracing the shapes through the gripper. (1 repetition each)

Outcome measure –

(1) MoCA scale –

The Montreal Cognitive Assessment (MoCA) is a screening tool used to assess cognitive function and detect mild cognitive impairment (MCI).

(2) Fugl-Meyer Assessment (FMA) scale-

It is widely used clinical tool to assess motor function, balance, sensation, and joint function in individuals who have had a stroke.

However, in this study, the following scale components are checked Motor function, joint ROM, sensation, joint pain of upper limb.

3. RESULT

Pre and Post assessment is taken.

TABLE NO. 1 STATISTICAL ANALYSIS : (Age)

Mean	48.2
SD	8.871

TABLE NO. 2 - MoCA scale for Cognition.

	Mean	SD	R value	P value	Result
Before Treatment	13.1	2.280	-0.9864	< 0.0001	Extremely Significant.
After Treatment	21.9	2.076	-0.9771	< 0.0001	Extremely Significant.

The average MoCA score increased significantly from **13.1** (indicating cognitive impairment) to **21.9** (indicating improved cognitive function) after treatment. This represents a **substantial recovery in cognitive function**.

TABLE NO. 3 Fugl Meyer Assessment.

(a) Motor Function.

	Mean	SD	R value	P value	Result
Before Treatment	34.7	3.261	0.9639	< 0.0001	Extremely Significant.
After Treatment	58.6	4.054	0.9860	< 0.0001	Extremely Significant.

The motor function scores significantly improved after treatment, with the mean score rising from 34.7 to 58.6. This improvement is both statistically significant and practically meaningful, as the R-value indicates a strong correlation between the pre and post-treatment assessments.

(b) Joint ROM.

	Mean	SD	R-value	P value	Result
Before Treatment	13.2	2.524	0.9809	< 0.0001	Extremely Significant.
After Treatment	19.6	1.905	0.9592	< 0.0001	Extremely Significant.

There was a significant improvement in joint ROM after treatment, with the mean score increasing from 13.2 to 19.6. The R-value indicates a very strong correlation, suggesting that the change in ROM scores is consistent and significant.

(c) Sensation.

	Mean	SD	R value	P value	Result
Before Treatment	5.4	1.102	0.9456	< 0.0001	Extremely Significant.
After Treatment	10	1.438	0.8269	< 0.0001	Extremely Significant.

The sensation scores also show a significant improvement, with the mean score rising from 5.4 to 10.0. This result, supported by a strong R-value, suggests that the treatment had a profound effect on improving sensory function.

(d) Joint Pain.

	Mean	SD	R value	P value	Result
Before Treatment	11.8	2.069	0.9728	< 0.0001	Extremely Significant.
After Treatment	19.2	2.212	0.9766	< 0.0001	Extremely Significant.

Joint pain significantly improved after treatment, as the mean score increased from 11.8 to 19.2. The strong correlation (R-value = 0.9728) and the extremely significant P-value show a clear and reliable improvement in pain levels.

Thus, The treatment has significantly improved **cognitive function**, as measured by the MoCA scale. The results are both **statistically and clinically significant**, demonstrating that the intervention had a marked positive effect on cognition. The results also reveal that the treatment profoundly impacted various aspects of individuals' physical abilities. Specifically, participants experienced notable improvements in motor function, joint range of motion (ROM), sensory perception, and reduction in joint pain measured by Fugl Meyer Assessment scale. These advancements are not only statistically significant but also clinically meaningful, underscoring the effectiveness of the intervention in enhancing overall mobility and quality of life for those involved.

4. DISCUSSION

This study, named "Effectiveness of Brain Gymnasium for Motor and Cognitive Impairments through Unaffected Hemisphere in Post-Stroke Individuals" aims to evaluate the usefulness of a brain gymnasium program in enhancing motor and cognitive skills. This study targeted the upper limb.

Research conducted by Xin Wen, et al, found that combining Motor Therapy (MT) with conventional occupational therapy can significantly improve upper extremity motor performance and enhance the ability of stroke patients to perform daily activities. The study suggests that MT can serve as an effective adjunctive treatment for upper limb motor function rehabilitation within the first six months following a stroke. However, MT did not appear to have a significant additional effect on improving the participation in activities for stroke patients, at least according to the findings of this study. [20]

Also, a previous study done by Hsu HY, et al stated that incorporating mirror therapy into a virtual reality (VR) system may improve motor recovery in chronic stroke patients. This study compares the effects of conventional occupational therapy (COT), mirror therapy (MT), and VR-based mirror therapy (VR-MT) on upper limb function in these patients. In a single-blinded randomized controlled trial, 54 chronic stroke patients were assigned to COT, MT, or VR-MT groups. Each underwent 20 minutes of task-specific training followed by 30 minutes of their assigned therapy, twice a week for 9 weeks. The Fugl-Meyer motor assessment for upper extremities (FM-UE) was measured at baseline, post-intervention, and at a 12-week follow-up. Of the participants, 52 completed the study. While there were no significant differences in overall FM-UE scores (GEE, P = .075), improvements were observed in the wrist sub-score (GEE, P = .012) and the box and block test (GEE, P = .044). VR-MT appears promising for enhancing upper extremity function in chronic stroke patients, warranting further investigation. [21]

“The Role of the Unaffected Hemisphere in Motor Recovery After Stroke” Axel Riecker,et al have highlighted the significant role of the ipsilateral (non-affected) hemisphere in recovering motor function post-stroke. We posited that relevant areas in the ipsilateral motor system are closely linked to motor demands. Using functional magnetic resonance imaging (fMRI), we studied eight patients with chronic left hemisphere striatocapsular infarctions who had achieved excellent recovery, comparing them to eight age-matched controls. Our results showed a linear increase in hemodynamic response in the left supplementary motor cortex (SMA) and left primary sensorimotor cortex (SMC) with finger movement frequencies for both groups. Notably, the patient group exhibited a linear increase in the right premotor cortex (PMC) and right SMC at higher tapping frequencies. These findings affirm enhanced bihemispheric recruitment of motor representations after subcortical strokes. The activation of the contralesional SMC indicates positive adaptive responses, akin to the bilateral activation observed in healthy individuals executing complex movements. [17]

This study was aimed at combining two different concepts Mirror box therapy and using the unaffected hemisphere to achieve motor and cognitive skills in the affected upper limb. the treatment protocol is structured into two distinct phases aimed at facilitating recovery through targeted exercises and sensory stimulation. Phase 1 emphasizes preparatory breathing exercises to help patients establish a calm focus before engaging in more dynamic activities. Phase 2 involves bilateral and simultaneous exercises that use auditory and visual biofeedback to improve motor recovery. In this phase, sensory stimulation is applied to the affected upper limb while the unaffected upper limb performs exercises. This technique promotes neuronal plasticity and strengthens the brain's connection to the affected arm. There were also proprioceptive neuromuscular facilitation (PNF) exercises to improve strength and coordination. Additionally, hand exercises are included to bolster cognitive and motor skills. Overall, this comprehensive approach not only encourages physical rehabilitation but also promotes mental engagement, ultimately aiding in the patient's overall recovery process.

The intervention has resulted in a significant enhancement of cognitive function, as measured by the Montreal Cognitive Assessment (MoCA) scale. The findings demonstrate both statistical and clinical significance, indicating that the treatment has had a pronounced positive impact on cognitive capabilities. Furthermore, the intervention has substantially affected various dimensions of the participants' physical abilities. Specifically, there were notable improvements in motor function, joint range of motion (ROM), sensory perception, and a reduction in joint pain, as assessed by the Fugl-Meyer Assessment scale. These improvements are not only statistically significant but also clinically relevant, emphasizing the efficacy of the intervention in improving overall mobility and quality of life for the participants involved.

Thus, in conclusion, the findings of this study indicate that the brain gymnasium through the unaffected hemisphere was effective in improving the motor and cognitive skills in post-stroke individuals.

5. CONCLUSION

In conclusion, this study shows that the brain gym program, which utilizes the unaffected hemisphere of the brain, significantly improved both cognitive and motor functions in individuals who have suffered a stroke. By combining sensory stimulation, bilateral exercises, and targeted therapies such as mirror box therapy and proprioceptive neuromuscular facilitation (PNF), participants experienced substantial improvements in motor function, joint range of motion, sensory perception, and cognitive abilities. The positive results, assessed using the Montreal Cognitive Assessment (MoCA) and Fugl-Meyer Assessment (FMA), demonstrate the effectiveness of this intervention in promoting neuroplasticity and functional recovery. These findings suggest that focusing on the unaffected hemisphere during rehabilitation can greatly enhance recovery after a stroke, providing valuable insights for therapeutic strategies in neurological rehabilitation.

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Ethical Clearance -

This study was approved by Institutional Ethical Committee of Krishna institute of medical sciences deemed to be university, Karad (Protocol number 256/2024-2025)

Statement of Conflict Of Interest -

We claim that there is no conflict of interest in the content of this study.

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