Bioscene

Bioscene
Volume- 22 Number- 03
ISSN: 1539-2422 (P) 2055-1583 (O)
www.explorebioscene.com

Role of Mirror Neurons and Action Observation Therapy on Lower Extremity Functional Reeducation among Stroke Survivors –A Narrative Review

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Abstract: Among people who have experienced a stroke, 72% have motor impairments in the lower limb[1] It is a common observation that individuals with hemiparesis exhibit asymmetrical weight bearing inadequacy –static standing posture & during functional movements. This asymmetry has been associated with impaired physical performance, balance and may contribute to disordered gait .The approach of this study is to find effect of mirror therapy and action observation therapy on lower extremity motor recovery after stroke. **Hypothesis:** there is significant effects of mirror therapy and action observation therapy on lower extremity motorexecution. Among the assumptions regarding the functional role of mirror neuron, the first one is expressing movements related to those registerd into visual and auditory sense in exercise. This means understanding of the observed exercise objectives andprojecting it in exercise. The ventral premotor cortex andinferior parietal lobe control these reactions. The second assumption is about is realising the conceived emotional situation into motor response. Insula and rostral cingulated control these reactions Conclusion action observation therapy is a unique rehabilitation approach it plays a crucial role in accelerating thet motor recovery Larger improvements in skills can be expected if action observation training is applied to patients in combination with the training currently used in interventions for rehabilitation. In motor imagery intervention, stroke patients with hampered mobility can activate the brain circuits by imagining movements, and active participation can be encouraged through the movement. In stroke patients who performed exercise imagery training, asymmetry of the gait pattern improved in the heel strike phase on the involved side, and the training can also be used to improve the relearning of daily tasks afteracute phase of stroke. Weight shifting interventions for hemiplegic patients enhances the inculsion of exercise imagery training Stroke patients who were asked to imagine normal gait to train the normal movement of foot showed improved parameters of gait pattern. Mirror neurons are a unique set of neurons, which are ‘‘resonate’’ in response to the elementary motor acts (e.g., finger lifting, precision grip) that form theobserved action and represent an ‘‘observation–execution matching mechanism’’, which can unify the sensing and execution of an action. The mirror system activation of premotor cortex and parietal areas are influence motor cortical outputs trans synaptically hence shifting motor cortical output excitability and in that each neuron within M1 appears toparticipate in the projection to multiple muscles and motor actions. The scenarios are designed to induce a cognitive process in which a subject imagines himself/herself acting as the agent in the displayed movement situation. Due to uniqueness of this type of interaction and its therapeutic potential, its relationship to passive observation and imitation during observation has been studied

Keywords: Neural Plasticity, axontomesis, action observation, mirror neurons, synapses, brain circuit, observation-execution, matching mechanism, prefrontal cortex, resonate, precision grip

Stroke or brain attack is non invented loss of normal neurological function caused by obstruction of blood flow to brainis the most commonly affecting about 80

percent of healthy individuals is **ischemic stroke** which occurs due to disruption in blood flow resulting in lack of essential oxygen and nutrients. **Hemorrhagic stroke** occurs when blood vessels rupture, causing involuntary loss of blood in or around the brain.[2]The anterior cerebral artery supplies the medial aspect of the cerebral hemisphere (frontal and parietal lobes) and subcortical structures, including the basal ganglia (anterior internal capsule, inferior caudate nucleus), anterior fornix, and anterior four fifths of the corpus callosum [1]

Weakness (paresis) is found in 80 to 90 percent of all individual affected with stroke and becomes a major contributory factor in disability. Patients face difficulty in generating the force which plays vital role in initiating and controlling movement. The severity of weakness is related to the remote area affected and size of lesion in the brain and its variety ranges from a complete inability to achieve any palpable contraction to measurable deficit in force production. Deficits on the contralateral, side typicallyinclude hemiparesis (opposite UE and LE).[1]

The most common characteristic of ACA syndrome is contralateral hemiparesis with greater involvement of the lower extremity because the somatotopic organization of the medial aspect of the cortex includes the functional area for the lower extremity [2]

Among people who have experienced a stroke, 72% have motor deficits in the lower limb[1], it is a common observation that individuals with hemiparesis exhibit difficulty in weight bearing in balanced way – static stability & during functional movements. This deviation has been correlated with deficit in physical performance, balance and may contribute to deviation of the gait.[3]

The conventional stroke rehabilitation training yields good rubrics to improve the physical performance, dynamic and static stability and coordinated pattern of the gait. Traditional Stroke Training involves the Passive movements, passive stretching, free exercises and Gait training[3]. Many varieties of rehabilitation intervention have been utilized to enhance ability after stroke Rehabilitation can be used as adjunct for stroke survivors to ambulate independently with adequate speed and endurance.[4]

Various approaches to stroke rehabilitation, such as: the facilitation technique Including proprioceptive neuromuscular facilitation (PNF) techniques, Brunnstrom's approach (neurophysiological approach, Bobath's approach (neuro developmental approach) therapeutic electric stimulation, electromyographic biofeedback, intensive rehabilitation therapy ,constraint-induced therapy have been studied to improve the functional recovery of hemiplegia due to brain damage For the repeated voluntary movement of hemiplegiclimbs to strengthen neural networks to realize voluntary movement, and especially when they are influenced by a synergic pattern the degree of the recovery of voluntary movement

of hemiplegic limbs may depend on the repetition of voluntary movement assisted by facilitation techniques[5]

Traditionally, physical therapy for patients with hemiparesis in the weeks after their stroke consist of therapeutic intervention based on neuromuscular reeducation, as well as on the practice of pre walking functional task such as transfer activities, weight shifts in sitting or static position and the maintenance of unassisted stance[6]

Mirror therapy, another exercise method using visual information, was first introduced by Rama chandran and Roger Rama chandran as a therapy using visual stimuli to reduce the phantom pain of amputees.[7] Mirror therapy is potentially a very innovative intervention in stroke rehabilitation because of its simplified protocol[8] Lin KC et al evaluated afferent stimulation and mirror therapy for rehabilitating motor function, motor control, ambulation, and daily functions after stroke[9]

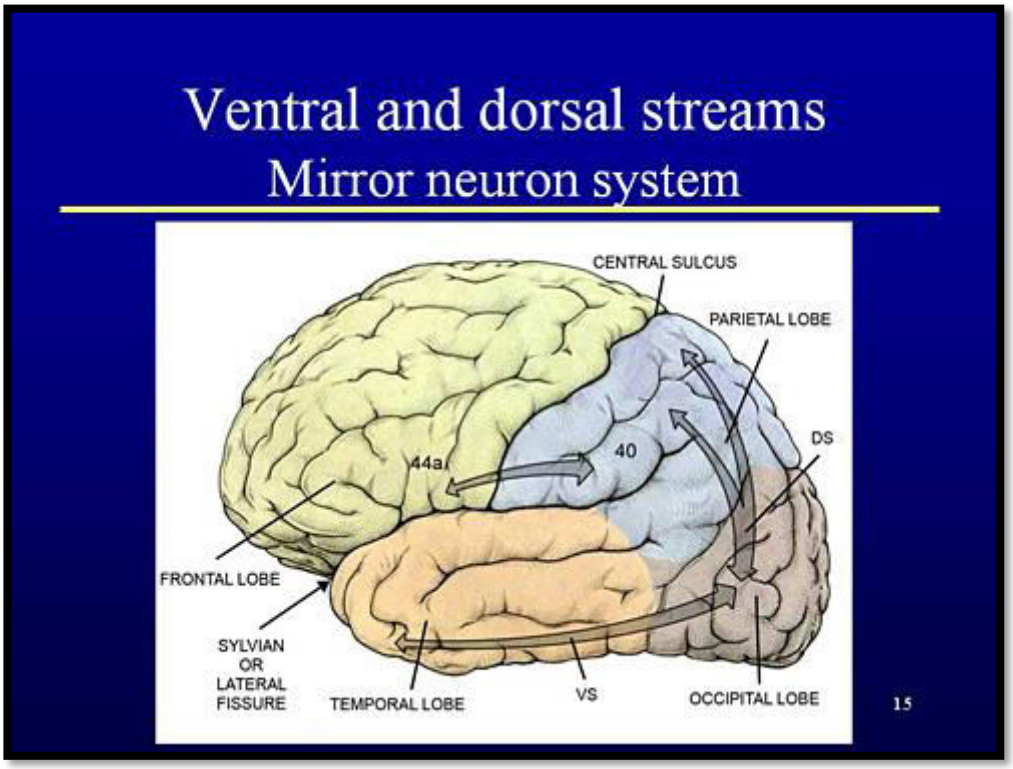

Plate 1: Mirror neuron system

The principle of mirror therapy is simplified: When observing into the mirror, the patient observes the reflection of the sound limb positioned as the hampered limb when performing motor or sensory exercises with the non-affected limb the reflection inthe mirror is often perceived as the affected, paretic limb. This strong visual cue from the mirror can therapeutically be used to improve motor performance and the perception of the hampered limb[10] the use of mirror therapy in post-stroke patients involves a re-assemblage of the body image in the

sensorimotor cortex, which can generate movement limitations, classified as ‘‘learned paralysis’’. In fact, the fibres that extend from the brain to the spinal cord are deprived of oxygen and suffer an injury, causing a real paralysis. In addition to this, in the early stages of cerebral damage, the penumbra area presents a cellular swelling, temporarily leaving neurons with little or no conduction property.Moreover, during its dormant period, the brain receives only negative visual feedback; this will possibly promote a form of learned paralysis, due to residual mirror neuron functioning. In this case, mirror therapy can potentially reactivate the cortical motor neuron Therefore mirror therapy has been used in many clinical instances because it promotes the functional recovery of a wide range of sensorimotor disorders, such as post-stroke hemiparesis[11]

Mirror neurons have been associated with various forms of human behaviors: imitation, mind theory, new skill learning and intention reading This means that we mentally rehearse or imitate every action observed, whether a somersault or a subtle smile, indicating that these cells are used to learn everything from the firstbasic steps to more graceful accurate movements. Therefore, imitation is involved in learning through the transformation of visual inputs encoded into action by the observer While observing the behaviour of others, the nerves in the observer’sbrain involved in such behaviour are activated.[12]

AOT is a novel rehabilitation approach exploiting this mirror mechanism and its potential role in motor learning for motor recovery. Larger improvements in skills can be expected if action observation training is applied to patients in combination with the training currently used in interventions for rehabilitation.[13]

The term ‘‘neuroplasticity’’ is used to describe the ability of neurons andneuron aggregates to adjust their activity and even their morphology to alterations intheir environment or patterns of use. The term encompasses diverse processes, asfrom learning and memory in the execution of normal activities of life, to dendriticpruning and axonal sprouting in response to injury. Improvements in motorperformance after brain damage through rehabilitation can be thought of as a motorrelearning process whereby lost action patterns are restored and new compensatoryaction patterns are acquired to re-establish motor faculties. Furthermore, motorrelearning following brain damage appears to be supported by neural plasticity withinresidual brain regions that resembles that seen in the intact brain during normal motorlearning. The neurobiologicalmechanisms of plasticity and spontaneous recoveryduring the initial days and weeks after stroke have been reasonably well characterizedusing animal models. These mechanisms include cell genesis, functional plasticity,and structural adaptations, such as axonal sprouting and synaptogenesis.AOT is a novel rehabilitation approach exploiting this mirror mechanism andits potential role in motor learning for motor recovery. Larger improvements in skillscan be expected if action observation training is applied to patients in combinationwith the training currently used in interventions for rehabilitation.

mirror therapy found that the primary motorcortex, which is involved in the movements of the otherside extremities, was euphoric by only analyzing the sound extremities in mirrors. The finding depicted that thefunctional organisation of motor systems is associated notonly by the active movements of the ipsilateral extremities,but also by passive observation of the movements ofthe opposite extremitiesTherefore, mirror therapy could play a crucial rolein learning a new skill or understanding the behaviour ofothers, which can be utilized to encourage stroke patients [15].Mirror therapy is performed on the non affected side bymoving the limbs of stroke patients; the movement ofhampered limbs through the reflection in the mirror shows avisual illusion of normal movement. This method fortreating a brain insult is based on the mechanism of synapticreorganization.It has been shown that functional organization of the motor system, including the primary motor cortex, can be
modulated by both ipsilateral limb movement and passive observation of movement of the contralateral limb Activation when a subject is doing motor tasks canalso occur in the bilateral inferior parietal area, the supplementarymotor area, and in the premotor cortex.[18]Furthermore, it was demonstrated that central adaptations occur innetworks controlling the paretic as well as the nonparetic lowerlimb after stroke. Actions generated using motor imagery adhere to the same movement rules and constraints that physicalmovements follow, and the neural network involved in motor imagery and motor execution overlap, primarily in the premotor and parietal areas, basal ganglia, and cerebellum.[18]
The principle of mirror therapy is simple: When lookinginto the mirror, the patient observes the reflection of theunaffected limb positioned as the affected limb. Whenperforming motor or sensory exercises with the non-affectedlimb, the reflection in the mirror is often perceived as self-awareness, spatial attention and recovery fromneglect such as the superior temporal gyrus have been shown to be activated by mirror therapy [11–13]Despite emerging evidence regarding the effectivenessof mirror therapy in stroke patients, one systematicreview has shown that many variations in treatment protocols for mirror therapy still exist, such as the type of movement performed. For example, patients have been instructed to move the unaffected limb only [(14–16)] or both limbs in a synchronized manner, as much as possible [14]Additionally, therapists have supported the movements of the affected limb in one studythe affected, paretic limb. This strong visual cue from themirror can therapeutically be used to improve motor performanceand the perception of the affected limb.
Mirror neurons have been associated with various forms of human behaviours: imitation, mind theory, new skill learning and intention reading[15]. This means thatwe mentally rehearse or imitate every action observed, whether a somersault or a subtle smile, indicating that these cells are used to learn everything from the first basic steps to more graceful accurate movements. Therefore, imitation is involved inlearning through the transformation of visual inputs encoded into action by theobserver While observing the behaviour of others, the nerves in the observer'sbrain involved in such behaviour are activated.

Stroke patients' ability to properly react to various environments and tasks is decreased because of decline in left/right weight transfer ability, time of affected side lower limb support, and limit of stability. also, their physical disturbance instanding is increased as much as two times, compared withnormal persons of the same In exercise imagery training, movement is imaginedin the mind without any physical actions[12]. The imagery induces information processing activity similar to performance of the real task, promoting the learning of motorfunction. motor imagery increased dynamic balance ability by activating the neural system. These results suggestthat in the motor imagery training with proprioception program, activation of the cerebrum and cerebellum affected proprioception, and the visual and vestibular organs responsible for balance ability, in particular, that the activation of the proprioception sensing the position and movementsof joints affects the balance ability.[16]

Action observation therapy is a unique rehabilitation approach it plays a crucial role in accelerating the t motor recoveryLarger improvements in skills can be expected if action observation training is applied to patients in combination with the training currently used in interventions for rehabilitation. In motor imagery intervention, stroke patients with hampered mobility can activate the brain circuits by imagining movements, and active participation can be encouraged through the movement. In stroke patients who performed exercise imagery training, asymmetry of the gait pattern improved in the heel strike phase on the involved side, and the training can also be used to improve the relearning of daily tasks after acute phase of stroke. Weight shifting interventions for hemiplegic patients enhances the inclusion of exercise imagery training Stroke patients who were asked to imagine normal gait to train the normal movement of foot showed improved parameters of gait pattern. Mirror neurons are a unique set of neurons, which are "resonate" in response to the elementary motor acts (e.g., finger lifting, precision grip) that form theobserved action and represent an "observation–execution matching mechanism", which can unify the sensing and execution of an action. the mirror system activation of premotor cortex and parietal areas are influence motor cortical outputs trans-synaptically, hence shifting motor cortical output excitability and in that each neuron within M1 appears to participate in the projection to multiple muscles and motor actions.[17-18]
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Acknowledgement

First and foremost I would like to dedicate this work to all those who contributed to various researches and studies done earlier in the field of physiotherapy and to all those who contributed a lot to add to my knowledge of neuroscience

I express my thanks to all the staff members in Parul Institute of Physiotherapy for their help and valuable suggestions.

I owe this to my lovely parents for their constant support, care and motivation through their blessings.

Last but not the least I would like to thank all the subjects of my study without whom this task would not have been possible. I thank all those who have helped me all the while.

Research funds

No financial or material support of any kind was received for this narrative review

Conflict of interest

No conflict of interest by any other member.