1. Introduction

Over 40 years, the classic definition for stroke or cerebrovascular accident (CVA) proposed by World Health Organization (WHO) is still in the use of current clinical practice of medicine. Globally stroke is defined as "rapidly developing clinical signs of focal (or global) disturbance of cerebral function, lasting more than 24 hours or leading to death, with no apparent cause other than that of vascular origin".[1] However advancements in science and technology have led to an updated definition in the 21st century. The revised definition for a stroke is "acute cerebrovascular syndromes which incorporate subclinical/silent stroke, Infarction or hemorrhage in the brain, spinal cord, or retinal focal injuries and cerebral venous thrombosis based on their clinical findings with persisting symptoms or signs ≥ 24 hours or until death, associated with neuropathological and imaging methods".[2]

Despite preventive measures and an advanced health care system the burden of strokes is reported to be a serious and disabling public health problem both in developed and developing countries.[3] The Stroke Expert Group from the Global Burden of Disease Study in 2010 reported that the stroke is the second single most common cause of death in the world causing 6.7 million deaths each year and also accounts for almost 1 in 8 (11.9%) deaths worldwide. With the global prevalence of 33 million, 16.9 million people are reported to be first ever stroke, among them 31% (5.2 million) first strokes were also reported to be in those less than 65 years of age. It is assumed that the burden of disease (disability, illness and premature deaths) caused by stroke is set to double worldwide by 2030.[4]

In India, epidemiological stroke profile studies from different parts of the country had witnessed the occurrence of strokes as a silent epidemic across the nation. These studies also explored significant increases in prevalent, mortality and disability – adjusted life years (DALYs) in the younger group of individual under 45.[5-8] Further, it was found that depending upon the extent, mechanism and location of the vascular lesion, stroke survivors were challenged with persistent neurological deficits or impairments such as hemiparesis, visual and speech disturbances and cognitive and perceptual disorders which could result in a loss of productive life and also in adverse socioeconomic and emotional consequences to the individuals, their family and community.[9,10]

Balance and mobility are important fundamental core sets for physical functioning. They provide a basic foundation for a wide range of functional activities to be performed optimally and independently. The functional goals of the intact balance control system is 1) to maintain postural alignment 2) to facilitate movement transitions between postures 3) to achieve equilibrium control in response to external perturbations by flexible postural control muscle synergies. Balance is also an integral component for functional mobility motor skills such as getting up from a chair, standing while performing upper extremity reaching tasks, walking, and turning. It is an essential part of the functional activities of daily life.[11-13]

Balance is a multifactorial phenomenon and results from interactions between many physiological systems involved in postural control mechanism, environmental and functional context.[13] Many factors have been reported to influence balance functions after a stroke and some of these include abnormal muscle tone in the affected leg, reduced muscle strength, proprioceptive deficits, muscle tightness with a loss of range of motion from the paretic lower limb, motor incoordination, problems in multisensory processing (visual, vestibular and somatosensory) and integration, cognitive and perceptual problems.[14-20] Secondary to the stroke hemi paretic subjects were also reported with deficits in the postural control mechanism such as increased postural sway and an asymmetric pattern of weight distribution while leading to quiet standing, abnormal and delayed postural responses (anticipatory and reactive postural adjustments) in the lower extremity muscles, reduced limits of stability when meeting changing task demands. All these deficits contribute to challenge the static and dynamic balance motor skills of stroke victims.[17,18,21]

Balance is an essential prerequisite to perform basic mobility skills safely and independently. Loss or restrictions in mobility is another major concern in stroke survivors as it leads to a sedentary lifestyle and development of other secondary complications like cardiovascular deconditioning, osteoporosis, musculoskeletal tightness and contractures.[22] Walking ability has been an important domain in mobility functions and to regain functional ambulation is also reported to be a primary goal for many stroke survivors.[23,24] Previous studies on the determinants of walking ability had reported physical parameters such as level of motor recovery and motor control, balance, paretic muscle strength, sensory impairments, standing postural control, spasticity, cardiovascular fitness and psychosocial parameters such as balance self-confidence are affected by decreased walking speed and endurance components in walking capacity.[25-7] Following a stroke the impact of reduced balance ability and its association with limited mobility skills can have a significant impact on the daily activities, community reintegration and quality of life of the patients.[28-30]

Emerging evidence suggests that deficits in muscle strength manifested as hemiplegia (severe or complete loss of motor function) or hemiparesis (mild-moderate weakness) on one side of body are considered prominent primary impairments and are responsible for compromised motor functions in the period of post stroke recovery.[31] Post stroke weakness is a broad phenomenon which includes slowness to produce force, impaired force magnitude, impaired muscle endurance, and difficulty in producing and sustaining muscle force effectively, within the context of a task.[32-35] The severity of lower extremity weakness is also found to be a major limiting factor in the performance of functional tasks, in daily activities including sit-stand, gait, stair-climbing and transfers. This in turn, impacts the patients and walking capacity and functional independence and leads to a greater risk of fall.[36,37] Reduced strength in lower extremity paretic muscles has found to be in strong association with motor performance, balance and gait related mobility tasks.[38]

Along with the medical management, rehabilitation is to facilitate the best recovery in all phases of post stroke care. Well-organized multidisciplinary rehabilitation teams from various health care professionals are engaged to identify and quantify the problems, set up short-term and long-term recovery goals, employ interventions supported by research evidence to potentially improve functional recovery among stroke survivors. Physical Therapy (PT) plays a major role in improving motor functions in interdisciplinary stroke rehabilitation. Till date there is growing body of knowledge and supportive evidence about the central role of physiotherapy in stroke rehabilitation.[39]

The traditional PT treatment methods were based on neurophysiological principles aimed to address impairments like modified muscle tone, training of non-functional movements with patients being passive recipients of therapy. The practical applications of these methods were based on therapist experience and clinical observation. There was a lack of scientific supportive evidence for its efficacy for clinical practice. [40]

In the 1980s motor learning approaches focused on addressing activity level rather impairments.[41] Task-specific training (TST) incorporates the key principles of neural plasticity, motor-learning elements and other scientific findings from cognitive and behavioral sciences. These training methods were based on patient activity level, emphasizing active participation and motivation with the practice of context-specific functional tasks.[42] TST in relationship with lower extremity rehabilitation was commonly addressed as incorporating real life daily basic functional tasks such as sit to stand, stepping, walking, crossing obstacles, stair climbing. Use was made of technology assistive devices such as robotics and the treadmill as also circuit class training with different substations aimed to improve balance, muscle strength, endurance and flexibility.[43-46] The literature review had shown moderate quality of evidence for TST, which involved functional tasks based on in and around everyday tasks or activities found to improve balance, ADLs, motor function and gait speed in sub-acute and chronic stroke survivors. However, the major limitations of the thus far published TST literature had failed to incorporate other therapeutic priming methods that may assist in both the quantity and quality of motor training benefits from TST in neurorehabilitation and hence, to accelerate these functional gain and recovery.[40,47]

Behavioural experience is considered one of the important powerful modulators in enhancing neural plasticity following central nervous system (CNS) injury. Physiotherapy interventions based on sensorimotor training provides this behavioral experience in order to reshape the brain by the use of two mechanisms: recovery and compensation.[48] Neural reorganization either in adaptive or mal adaptive way is also associated with the quantity and quality of specific training methods.[49] Recent advances in understanding the concepts of neural plasticity from animal and human stroke models had evolved several emerging treatment methods such as neural engineering (robotics), cognitive neuroscience involving a mirror neuron system (action observation and motor imagery), electrophysiology applications like noninvasive brain stimulation (transcranial brain stimulation) and diagnostic imaging as functional MRI aimed to maximize the best possible functional outcome in stroke survivors.[50,51]

Motor learning research findings from human and animal studies have shown that an effective neurorehabilitation treatment protocol delivers high numbers of repetitions with task-specific activity (400-600 repetitions per day) to enhance experience dependent neural plasticity for greater functional improvement.[52] However, in current stroke rehabilitation settings the delivered treatment dosages are not adequate to drive the neural reorganization due to various reasons. The limited numbers of treatment sessions during a clinical therapy session in the hospital set up and limited financial support make the patients discontinue the therapy. Unavailability of skilled therapists for home based programs, limited social support and transport also act as barriers to attend therapy sessions in outpatient rehabilitation services regularly.[7,53,54] Given these limitations, the therapist needs to integrate novel treatment strategies aimed at maximizing the practice opportunities to maintain the functional gain outside therapy sessions with minimal effort and also reduced use of cost resources.

Emerging evidences support that use of cognitive tools such as action/movement observation and motor imagery has been suggested as offline operations of the motor neural networks and may play a role in relearning motor skills.[55] At present the major challenge posed to physical therapy intervention in stroke recovery is to integrate novel treatment methods which are aimed at facilitating true motor recovery rather than the employment of compensatory strategies. Guided recovery by priming methods is desirable in a quantitative sense because more intense practice is needed to modulate motor learning. Guided recovery is also qualitatively desirable to improve motor pattern. The targeted treatment method should able to reconnect the damaged neural circuits with the intended goal of true motor recovery.[56]

Motor Imagery (MI) is the cognitive ability of an individual to mentally experience, rehearse and perform motor related actions as movements/ tasks without actually physically executing them.[57] Motor Imagery Training (MIT) or Mental Practice (MP) involves a training method for patients to repeat this imagined movement/task. It is aimed at reinforcing various other cognitive processes in motor control such as attention, memory, motivation. This will facilitate motor learning and reacquisition of motor skills in healthy individuals and in athletes during rehabilitation.[57,58] In current clinical practice, MI was found to be one of the core areas of interest for physical therapists to assist guided motor recovery. It was found to be useful to other rehabilitation research communities. Multiple clinical trials employing MI across diverse neurorehabilitation conditions from Stroke, Parkinson's, Multiple Sclerosis and Spinal Cord Injury was found to produce some positive effects in motor and functional recovery.[59-61]

In recent years there have been many critical reviews and extensive research findings which have explored the potential role of MP in stroke rehabilitation. The MI mechanism facilitates motor attention, preparation, planning or programming associated with greater activation of cortical-subcortical neural networks responsible for motor learning. Studies have shown that MP combined with Physical Practice (PP) facilitates neural plasticity, accelerates the rate of motor recovery and enables the relearning motor skills.[62,63] MP causes the repeating the movements/tasks mentally and without physical effort and thereby actively processes the various cognitive components of imagined movement/task such as planning, sequence, and direction. Therefore it can be considered as a potential therapeutic priming tool to facilitate true motor recovery. MIT is advantageous as a common self-practice treatment method, cost effective, self-motivating which would enhance motor learning and motor performance in stroke rehabilitation.[58,59,64]

A literature search was conducted to identify the efficacy of MP in stroke rehabilitation. Several systematic reviews which aimed at exploring the feasibility and efficacy of MIT have reported that a large number of clinical trials had assessed its benefits in relearning motor tasks related to upper extremity functions. They also highlighted a few, small sample size randomized controlled trials that evaluated the feasibility and efficacy of MIT in lower extremity functions specific to balance and mobility tasks and the result findings were further challenged by inconsistency in MIT framework and control group intervention.[65-68] Narrative reviews addressed to MP in neurorehabilitation have recommended to integrate the key elements of motor learning principles which includes stages of learning, types of motor skills, feedback, practice and also emphasizes strategies to maximize its functional equivalence with physical practice for maximal functional gain in stroke survivors. Whether modifying these MI factors produce beneficial to stroke community still needs to be addressed.[69,70]

1.1 Statement Of Problem

Effective physical therapy services are found to be a core element for motor rehabilitation in stroke survivors. Designing an optimal neurorehabilitation protocol should include a variety of recommended treatment methods integrated with the principles of motor learning to facilitate neural plasticity and functional recovery.

MP aims at manipulating the cognitive elements and the associated kinesthetic sensations of imagined motor action with the intention of improving physical performance. MIT is advantageous as a common self-practice treatment method. It is cost effective and self-motivating and will enhance motor learning and motor performance in stroke rehabilitation.

From the literature search and to the best of our knowledge there are limited retrievable controlled clinical trials that had incorporated task specific training with extensive practice of a wide variety of functional mobility tasks for their physical practice group. Further, incorporating MIT into the performance of simple functional tasks in order to enable the patient regain balance and mobility functions is not considered.

Muscle strength is found to be an important contributor to balance and mobility related functions in the case of a stroke. Studies have shown that MP has improved muscle strength in healthy persons and athletes. However the benefits of MP related to muscle strength have not been explored in stroke rehabilitation.

The Quality of Life is an important index in the rehabilitation service. However, there are no reported benefits of the lower extremity MIT program on stroke-related quality of life.

1.2 Aim of the study

The primary aim of study is to determine the effectiveness of combining Mental Practice with Physical Practice on Balance and Mobility in Ambulant stroke subjects.

1.3 Objectives of the study

The objectives of the study are as follows:

i) To study the effects of lower extremity task specific training (Physical Practice) aimed to improve balance and mobility in ambulant stroke survivors and also to study their long term benefits.

ii) To study the effects of combining task specific training with a mental practice training program incorporating lower extremity functional tasks (Physical plus Mental Practice) aimed to improve balance and mobility in ambulant stroke survivors and also to study their long term benefits.

iii) To compare the effectiveness of these two training program (Physical Vs Physical plus Mental Practice) to address all the domains of International Classification of Functioning, Disability and Health (ICF) model in stroke care services.

Body Structures and Functions	Activity	Participation
Muscle Strength paretic isometric muscle strength for flexors and extensors groups (Hip, Knee and Ankle)	Balance Berg Balance Scale (BBS) Mobility Functional Gait Assessment (FGA) 10-metre walk test (10MWT)	Quality of Life Stroke Impact Scale 16 (SIS-16)

1.4 Research Hypothesis

Physical plus Mental Practice would have better improvement in balance and mobility functions than Physical Practice alone in ambulant stroke survivors.