

Overview of gait rehabilitation in stroke

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Abstract

Stroke is the 2nd leading cause of death globally after ischaemic heart disease and is expected to rise more by 2030. The estimated incidence of stroke in Pakistan is about 250/100,000 individuals. Difficulty in walking is present in approximately 80% of stroke survivors. About a quarter of stroke survivors, even after receiving rehabilitation have residual gait impairments requiring assistance in activities of daily life. Almost half of stroke patients after being discharged will have episodes of fall, with majority of these falls occurring in activities like "turning". Gait is one of the key features to participate in community and occupational activities. Therefore, appropriate gait rehabilitation post stroke is crucial for functional independence and community ambulation. There are many approaches to gait rehabilitation based on different models of motor physiology and disease. Augmenting conventional therapies with novel techniques such as utilization of electromechanical means have improved gait rehabilitation in improving functions. The usage of technology in rehabilitation of patients with neurological deficits, is still novel in Pakistan. This review provides an overview of advancements in neurological and gait rehabilitation post stroke.

Keywords: Cerebrovascular accident, gait, muscle strength, rehabilitation, robotics, virtual reality.

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Introduction

Stroke is the second leading cause of death globally after ischaemic heart disease and is expected to rise more by 2030. Stroke has become a major public health concern in the developing countries, because of demographic transition of population. Although country wide statistics about stroke are not available for Pakistan, but the reported incidence is 250/100,000 population. It is

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estimated that around 350,000 new cases of stroke occur every year in Pakistan.¹ Mobility loss is a major post stroke impairment and leaves most stroke survivors somewhat functionally disabled.² Difficulty in walking is present in approximately 80% of stroke survivors. A quarter of stroke survivors even after rehabilitation have residual gait impairments requiring full assistance after hospital discharge, thus resulting in difficulties in performing basic activities of daily life. ³ There is motor weakness, deficit in motor control, proprioceptive loss and/or ataxia associated with hemiparetic gait pattern. Step and stride length, step width, cadence and velocity are usually decreased in hemiparetic gait. Stance duration and single leg support duration on paretic side is decreased, however swing phase is increased and vice versa on non-paretic side. Almost 70% stroke survivors have history of fall during first year after stroke.⁴ Walking, especially, turning around during activities is the biggest issue leading to even falls among people after discharge. Activities requiring turning around are major risk factors for fall, thus reducing efficiency for normal daily activities indicating it as major target for gait training. Stroke is quite significant in terms of burden it causes on economy, quality of life and caregivers because of the impairments it causes.² The patients with stroke have a lower quality of life as compared to other people. This is because of emotional and physical changes. These factors, which patients with stroke face negatively affect daily routine, like work and driving skills, resulting in a poor quality of life. This may result in social isolation due to lack of community ambulation.^{3,5}

Post stroke gait rehabilitation

Various approaches to post stroke gait rehabilitation are based on different models of motor physiology and disease recovery, with approaches focussing on motor impairments during linear gait only as opposed to adaptive walking ability. A multidisciplinary coordinated post stroke rehabilitation is essential to reduce health care burden associated with stroke and results in higher independence rates. Electromechanical means for gait training help regain walking ability and treadmill use with or without body weight support improves walking speed and endurance. Augmenting conventional therapies with novel techniques have improved stroke rehabilitation to reduce disability and improving functions. Gait training

programmes may include a combination of conventional techniques like muscle strengthening, neurodevelopmental or facilitation technique, mental practice with motor imagery, circuit training, functional electrical stimulations, treadmill training, use of ankle foot orthoses, botulinum toxin injection in the spastic muscles or advance gait training options like task-specific gait training, electromechanical and robot-assisted gait training and virtual reality.³ Some are discussed below.

Conventional Gait Rehabilitation:

Neurodevelopmental or facilitation techniques

This technique incorporates knowledge of neurosciences to its theoretical base, focussing mostly on three aspects: central nervous system plasticity, sensorimotor and learning control and muscle structures plasticity. A 2020 systematic review reported that Bobath technique compared to other techniques for gait rehabilitation is equally effective.⁶

Task oriented circuit training

A combination of 6 or more exercises with set number of repetition and short rest time in between is circuit training. Other than a focus on progressive repetitive practice of functional tasks and dynamicity of group, a key component of this training is that the group has more than two participants per therapist, resulting in a lower staff to patients' ratio. A systematic review conducted in 2018 reported use of task-oriented circuit gait training improves step length, width and cadence there by improving mobility and gait.⁷

Functional electrical stimulation (FES)

FES is a method of treatment in which electrical impulses of low level are applied to nerves or muscles to stimulate voluntary muscle activity, reduce foot drop, decrease spasticity, and lead to long-term sensorimotor cortical reorganization. A 2020 systematic review concluded that the use of FES on peroneal nerve stimulation improves gait speed.⁸

Advanced Gait Training:

Robotic devices

A robot is capable of mobility, with different levels of autonomy. Different types of robotic devices available for gait training include, Gait Trainer (RehaStim, Germany), G-EO (Reha Technology AG, Switzerland), Lokomat (Hocoma, Switzerland), Bionic Leg (Tibion Bionic Technologies, USA) and exoskeletons etc. A 2019 systematic review reported that use of robotics in post

stroke gait rehabilitation improves gait parameters including speed and step length variabilities.⁹

Virtual reality

Virtual reality is a relatively new tool in physical rehabilitation paradigm. It is defined as "an artificial, computer-based creation or simulation of a real-life situation or environment allowing the user to navigate through and interact with environment".¹⁰ It offers multiple benefits. The environments and situations that are not accessible can be stimulated and therapist can fully control and change these stimulations according to requirements giving the opportunity to bring the real-life situations to life for example going to market or playground etc. The patient motivation also improves due to interesting virtual environments leading to better patient engagement.¹⁰

A 2019 systematic review reported that spatiotemporal and functional parameters of gait can be effectively improved with VR based gait training.¹⁰

Treadmill Training

Treadmill training is effective for strengthening muscles, recognition of motor control for gait and balance training post stroke.¹¹

A systematic review concluded that use of treadmill for gait training is effective in improving walking distance in patients after stroke.¹¹ Treadmill training without or with body weight support is becoming popular in patients post stroke. Treadmill increases the amount of task specific training. Hesse and colleagues in 2003 reported that after treadmill training of 20-minutes post stroke, patients can perform almost 1000 steps, in comparison to conventional rehabilitation where only 50 to 100 steps can be performed in 1 session of 20 minutes. Body weight support, velocity and physical therapist's assistance can be adjusted according to the training intensity. However, it is a costly equipment and is not portable, so patients have to attend a suitable equipped health care facility. Multiple RCTs have reported benefits of treadmill training with or without body weight support in gait training of post stroke patients.¹²

Rotational Treadmill Training

Chenet al, in 2014 designed a novel rotational treadmill to target turning ability in stroke patients. This treadmill had circular motorized belt which made the patient walk in rotational or curvy manner instead of regular linear walk. They concluded that to improve turning ability, gait symmetry, muscle strength, and balance control for individuals with chronic stroke rotational treadmill training was a feasible and effective strategy. However,

this treadmill is not readily available in the market and its effect on other aspects of gait have not yet been elucidated.²

Split Belt Treadmill

A split belt treadmill has two belts each oriented for single leg and can be controlled independently. During training these belts can move at same or different speeds to change the walking pattern of the patients over treadmill. Most training starts with same speed (tied belt) followed by different speeds (split belt) and are finished again with tied belts conditions to train gait asymmetry. The speed of each belt, duration and other factors are adjusted according to the goal of training. Correction of step length asymmetry through the adaptation of gait characteristics to the perturbing locomotor environment is main objective of split belt training paradigm. The leg with shorter step length is placed on the belt with fast speed to augment step length asymmetry.¹³

A 2021 systematic review reported that split belt treadmill has positive effect in improving step asymmetry. However, further clinical trials are needed to evaluate its true effectiveness in post stroke gait rehabilitation.¹³

Benefits and limitations of Conventional Vs. Advanced Post Stroke Gait Training

Well-designed conventional gait training is cost effective, affordable, straightforward method that can be easily used by everyone and does not require extra training. The advanced gait re-education methods usually require technologically advanced costly equipment with special training in their use and are very costly. They are not widely available in all parts of the world.¹⁴

Advanced gait training methods provide task oriented, safe and intensive rehabilitation to people with mild to severe motor impairments. Other benefits include precisely controllable resistance or assistance, good repeatability, objective and quantifiable measures of subject performance and use of interactive biofeedback.¹⁴

Challenges in Pakistan

Gait rehabilitation after stroke is very crucial and is being conducted at different stages and levels. In most of the rehabilitation centres in the country, gait rehabilitation is mostly based on the conventional methods, however new emerging options like virtual reality, different forms of advanced treadmill training, and in some cases sensor-based training has also been incorporated for improving gait. However, these are not widely available. The main challenge is the cost of the equipment and lack of trained rehabilitation staff to use these technologies. Few centers

offering training gait using advance equipment are doing it mostly for research-based activities. The utilization of the recent evidence based advance methods on regular clinical bases is still not incorporated in the clinical setups of Pakistan.¹⁵

Recommendations

Allocation of budget should be done by government to train work force for managing and rehabilitating stroke patients. Collaborations at larger scale with different industries should be made to develop cost effective customized equipment. Dedicated stroke rehabilitation units should be established with advanced equipment and coordinated post stroke rehabilitation at every department of neurology in the public and private sector hospitals and should be staffed with trained personell.

Conclusion

Gait improvement is the major goal after stroke, making survivors independent in the community. Multiple different treatment approaches are available from conventional exercises to advanced methods. With time, more advanced methods are being developed. However, gait is a complex phenomenon. To effectively improve gait augmenting conventional therapies with novel techniques along with clinical skills and experiences are required.

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