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Review Article

Rehabilitation Strategies for Post-Stroke Motor Recovery: A Literature Review

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Abstract: The area of rehabilitation robotics has been looking for methods to improve the effectiveness of the treatment choices that therapists provide on a regular basis for disabilities ranging from neurological to muscular. To do this, a variety of robot treatment systems have been developed and researched. The purpose of this study is to summarise the field's future directions while focusing on rehabilitation techniques for post-stroke upper limb motor control, their clinical efficacy, and data analysis techniques. The discussion will also include new approaches that haven't been thought of or tried yet, such as deeper incorporation of virtual reality.
Keywords: Rehabilitation, Robot, Efficacy, Virtual, Reality.

Introduction

Stroke, which is the third most common cause of mortality in the US after heart disease and cancer, is characterised by a sudden, localised neurological deficiency brought on by a cerebrovascular abnormality. In the United States, there are around 600,000 new strokes and 180,000 recurrent strokes each year; in 1999, 1.1 million persons reported some level of functional disability as a result of stroke. Approximately 50% to 70% of stroke victims ultimately recover their independence, whereas 15% to 30% are left permanently disabled. 30% of stroke survivors need assistance walking at six months after their stroke, and 25% need support with ADLs. Successful rehabilitation will have significant public health consequences over the next decades given the danger of age-related stroke and the growing ageing population in the United States. The precise disabilities experienced after a stroke vary on the afflicted region of the brain. Common conditions that may be quite restrictive include aphasia, dysarthria, dysphagia, neglect, pain, cognitive impairments, sensory loss, and sadness. The major emphasis of this review is motor weakness since it may be the deficiency that is most visible to both the patient and an outside observer. The most frequent form of weakness, known as hemiparesis, occurs when an arm and a leg are both weak on the same side and accounts for 60% of cases. A powerful predictor of the severity of functional impairments is the degree of motor weakness[1].

The field of medicine known as rehabilitation medicine deals with and controls function, often known as "performance." Neurology and neurosurgery diagnose and treat acute strokes, but rehabilitation specialists take care of the function-related residual deficiencies in speech, self-care, and mobility. Teams of medical professionals, including physiatrists, occasionally neurologists, nurses, physical and occupational therapists, speech-language pathologists, social workers, and others, are in charge of managing stroke rehabilitation. The rehabilitation team employs a number of methods to enhance function after a stroke, including bracing, environment adjustment at home and at work, strengthening of weak and intact limbs, and preventing additional impairment. After a stroke, it's critical to differentiate between functional and motor recovery. Improvements in the power, quickness, or precision of arm and leg motions are referred to as motor recovery. Both therapies for spontaneous healing and rehabilitation contribute to these benefits. Improvement in performance, such as self-care or walking, is referred to as functional recovery. The type, severity, and resolution of motor deficits, the patient's capacity to learn and apply new skills, such as compensating with the intact extremities, and the characteristics of the rehabilitation therapy offered (its type, timing, quantity, frequency, etc.) all play a role in functional recovery, despite its complexity. Motor recovery may be compared to "getting better" whereas functional recovery is compared to "doing better." How much rehabilitation should prioritise compensation vs recovery is a hotly contested topic[2].

Mechanisms of Motor Recovery Following Stroke

A complex procedure is also involved in motor recovery. Natural recovery relies on reducing local edema, reperfusing the ischemic penumbra, and resolving diaschisis, or regions of metabolically depressed brain far from the infarction, in the hours to weeks after a stroke. Natural healing is passive; the patient makes neither an effort nor learns anything. [Intravenous and intraarterial thrombolysis, newly reviewed in this journal, aims to reduce infarction and restore the viability of the ischemic penumbra and contributes significantly to recovery.] The real reorganisation of damaged brain tissue in and around the affected regions may potentially contribute to motor recovery. This procedure is more aggressive and takes a lot longer. The unmasking of latent neuronal networks and increases in the absolute number and concentration of synapses on dendrites are likely connected to the underlying processes for late brain reorganisation. Long-term motor rehabilitation may benefit greatly by sparing the secondary motor cortex. The motor cortex may change the relative control of a particular body part because to this "rewiring". Additionally, it seems to be a unique consequence of the patient's experience. The main obstacle in stroke therapy is defining the ideal type, traits, intensity, and timing of this experience.

Recovery from Stroke: Current Concepts and Future Perspectives

In high-income nations, stroke is the most frequent reason for acute hospitalisation in neurology departments. Stroke incidence and prevalence are largely influenced by ageing, much as other vascular illnesses. According to the US National Centre of Health Statistics, the UK Stroke Association, and the German Medical Chamber, the average age of all stroke patients in Europe and the United States is between 70 and 75. According to the Australian Stroke Foundation and the CDC's stroke statistics, over 65-year-old individuals make up around two-thirds of all stroke patients. Recent research from the Global Burden of Disease (GBD) study group has shown that as people age, strokes become more important in terms of live years lost to death or morbidity. Due to better cardiovascular disease prevention in general, advancements in the acute stroke setting, such as specialised facilities (i.e., stroke units), and the development of recanalizing therapies, such as thrombolysis and thrombectomy, both age-standardized mortality and stroke prevalence rates have significantly decreased over the last three decades. Nevertheless, due of longer life expectancies and population expansion in the majority of nations, the absolute numbers of stroke fatalities and DALY are still increasing. These numbers are expected to rise sharply during the next 30 years. Additionally, according to demographic statistics, one in three stroke patients in 2050 would be 85 years of age or older. Therefore, in order to improve stroke outcomes generally, there will be a larger demand for enhanced neurorehabilitation as well as increased capacity in stroke care, particularly for elderly and extremely elderly patients[3].

Only a tiny fraction of patients are eligible for thrombolysis and thrombectomy, despite the fact that they are quite successful in lowering stroke-related morbidity and death. When compared to data published in bigger regional registries with tens of thousands of patients, the thrombolysis rate for single institutions may range up to 34% of patients. For instance, according to the Medical Chamber

Northrhine/Germany's 2018 Quality Report, around 14.5% of stroke patients in the Northrhine region of Germany in 2018 got thrombolysis. In 2018, around 5% of patients had thrombectomy as a therapy. Furthermore, after receiving thrombolysis or thrombectomy, most patients (> 50%) still have a profound neurological disability, although one that is far less severe than it would have been without therapy. Therefore, it is necessary to create novel treatments that enhance recovery. There haven't been any innovations like the ones used to treat acute strokes to yet. The reason for this is that we understand what causes a stroke (a blood clot in a vessel or its rupture) considerably better than we understand what causes function to return. Therefore, comprehension of the underlying (patho-) physiological processes is required to aid in the promotion of recovery[4].

Recovery from stroke

After a stroke, there are often many stages. According to the Stroke Roundtable Consortium, the acute phase would last during the first 24 hours, the hyperacute phase for the first 7 days, the early subacute phase for the first 3 months, the late subacute phase for months 4-6, and the chronic phase for months 6 and beyond. This distinction is made because post-stroke mechanisms associated to recovery are time-dependent. A cascade of plasticity-enhancing processes causes dendritic expansion, axonal sprouting, and the development of new synapses as early as hours after the start of cerebral ischemia. The most dramatic improvements also happen in the first few weeks after a stroke, with subsequent recovery, particularly in terms of motor symptoms, often hitting a relative plateau around three months.

Usually, spontaneous healing reaches its peak after six months, resulting in a sustained, or chronic, impairment. However, improvements of certain stroke-induced deficiencies may be made even in the chronic period with training or other treatments, especially for higher cognitive areas like language. While a clear division of post-stroke stages makes it easier to compare the findings of various research, it also runs the unique danger of seeing functional recovery as a discrete series of phases as opposed to an ongoing non-linear process. Even though both are considered to be in the same phase, i.e., the early subacute phase, it looks highly probable that recovery-related processes 10 days after a stroke significantly vary from those 80 days after a stroke. The issue of whether the same mechanisms underpin recovery for a particular phase is raised by the fact that recovery profiles substantially differ amongst individuals, with some patients healing better and quicker than others. Therefore, providing absolute numbers on time from stroke onset, such as weeks, in addition to further information about the level of impairment and stroke location, seems to be better suited to acknowledge the complex, nonlinear nature of stroke recovery than using labels like "subacute" or "chronic," which are frequently implicitly used to indicate a particular potential for improvement[5].

Patients with modest impairments are more likely to recover well after stroke than those with initially more severe deficits, according to a general rule of thumb. The 'proportional recovery rule' presupposes that patients can typically regain 70% (+/- 15%) of their lost function within 3-6 months following a stroke, with the lost function being defined as the hypothetical difference between normal function (for example, a full score in a motor test) and the patient's initial deficit. The proportionate recovery rule is a fascinating idea that bases recovery of function on a basic neurobiological mechanism that is unaffected by whether a patient gets high- or low-intensity treatment.

However, it has lately come under fire for being unnecessarily influenced by mathematical coupling and ceiling effects, which results in an overestimation of proportional recovery connections. Additionally, a sizable fraction of patients (referred to as "non-fitters") seem to deviate from the proportionate recovery rule. With a spectrum spanning from either displaying nearly no to very robust recovery, patients, particularly those with initially more severe impairments, depart from the proportionate recovery rule. Current theories of recovery are challenged by the fact that certain stroke patients with initially significant disabilities, including hemiplegia, may even recover within the first 10 days[6].

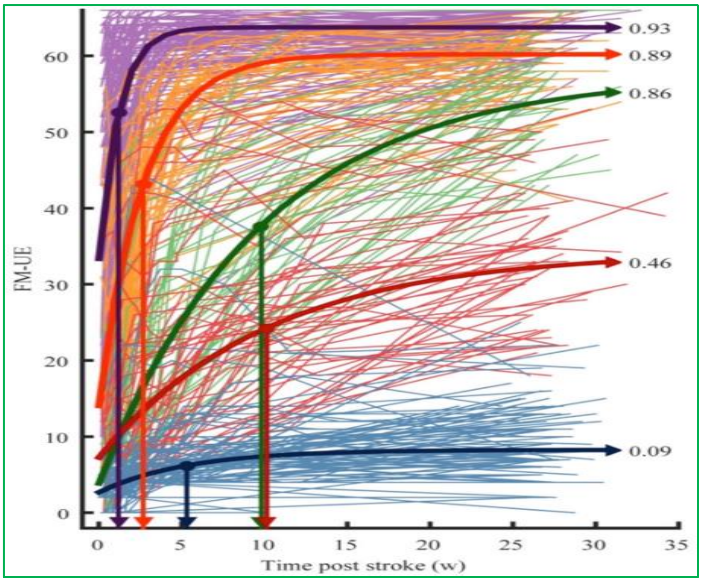

Figure 1. Motor recovery after stroke in a sample of n = 412 ischemic stroke patients based on the Fugl-Meyer upper extremity (FM-UE) score.

Imaging stroke recovery

With the use of non-invasive neuroimaging techniques, it is possible to identify the neurological mechanisms behind patients' functional recovery. Our understanding of the neuronal processes causing brain reorganisation following stroke has been greatly expanded, particularly via the use of functional magnetic resonance imaging (fMRI). Multiple fMRI investigations on individuals having a motor stroke have shown that activity is changed not just in the hemisphere that has been damaged, but also in the unaffected, or contralesional, hemisphere. For instance, compared to healthy individuals, unilateral motions of the hand afflicted by a stroke are frequently accompanied by increases in activity in contralesional sensorimotor regions. Within the first week after a stroke, there is evidence of a higher recruitment of the contralesional hemisphere, which is more likely to happen in individuals with more severe initial deficits. In contrast, in the first days after a stroke, ipsilesional activity is often reduced in individuals who are seriously afflicted. Other functional systems, such as the language system in aphasia patients, have also been documented to have similar impacts. Importantly, functional recovery in the motor system is correlated with initial increases in brain activity in both ipsi- and contralesional regions. These activity increases, however, are just a temporary phenomena in individuals who make a successful functional recovery three months later, according to longitudinal investigations. Patients with lasting impairments, however, particularly those with ipsilesional corticospinal tract injuries, often maintain overactivity of the contralesional hemisphere[7].

The functional significance of post-stroke activity alterations is a topic of continuing debate. Increases in contralesional activity, for instance, may be a mechanism supporting brain processing in the hemisphere with the lesion. Alternately, transcallosal disinhibition may lead to increased contralesional activity, which might then disrupt coordinated neuronal processing in the hemisphere with the lesion. Computational models of connectedness have shown to be highly helpful in separating the function of a specific location for the whole network. Here, the effective connection from fMRI time-series generated data has been precisely modelled using dynamic causal modelling (DCM). When DCM was applied to fMRI data taken while patients (10–7 weeks poststroke) moved the hand that had been injured by the stroke, it became clear that the contralesional primary motor cortex (M1) had an inhibitory effect on the activity of the ipsilesional M1. Notably, the degree of motor impairment was connected with the intensity of this inhibitory connection, with more impaired individuals exhibiting greater inhibition. These findings are consistent with the contralesional M1 playing a maladaptive function 2-3 months after the stroke. Importantly, longitudinal data showed that in the early days after a stroke, contralesional M1 influences ipsilesional M1 favourably. Patients who developed an inhibitory coupling had worse results, according to a correlation between DCM coupling changes throughout time and motor outcome. On the other hand, positive motor outcomes were related with greater increases in coupling from ipsilesional premotor regions to ipsilesional M1. The restoration of a network configuration lateralized to the ipsilesional hemisphere, thus mimicking the condition seen in healthy people, is thus connected to a favourable motor result following stroke. However, in individuals who have made a full recovery, the contralesional hemisphere may also play a supporting role[8].

Rehabilitation Strategies for Stroke Recovery

The main cause of long-term disability and neurological impairment in the United States and Europe is stroke, also known as cerebrovascular accident (CVA). A stroke may result in death or irreversible neurological impairment. Worldwide, fifteen million people have strokes every year, with around one third of them dying as a result. A stroke is brought on by a disruption in the blood flow to the brain, which results in the loss of brain functions. A blockage, a haemorrhage, or insufficient blood supply to the brain are the typical causes of this. As a consequence, the brain's damaged regions are no longer able to operate normally, which has a significant impact on the person. A stroke's effects may include paralysis in one or more limbs, limited mobility on one side of the body, and/or trouble comprehending and speaking. About 25% of stroke survivors have difficulties using their arm again at some point following the stroke. Usually, the major effect of a stroke is a motor function deficit in the arm and hand. The probability of having a stroke or any neurologically debilitating condition rises significantly with the population. Unfortunately, the world's ageing population, which will need care due to the incapacitating disorders connected with ageing, does not expand as quickly as the availability of physical or rehabilitation therapists. Additionally, private counselling sessions are pricey. Because of this, there is a need for other forms of repeated, unsupervised rehabilitation, such as using robotic equipment in treatment. As a result, there would be a greater selection of therapies available and more affordable solutions to the issue. Robotic equipment may be utilised to provide patients safe and interesting treatment sessions. A robot device that monitors changes in kinematics and forces can effectively adjust the level of treatment[9].

It is crucial to describe the many types of support that a robot may provide in order to comprehend the history of the role robotics has played as a rehabilitation alternative after stroke. The term "assistive robotics" (AR) describes a broad category of robots that are used in a variety of settings, including homes, hospitals, and classrooms. In order to classify robots according to the sort of interaction they have with the operator, the term "socially interactive robotics" (SIR) is used to describe robots whose primary functions are interactions between humans and machines. Last but not least, the term socially assistive robotics (SAR) was developed to designate a robot whose goals included intimate engagement with its human operator, assistance with repetitive tasks, and capturing quantifiable data in rehabilitation and learning[10].

Rehabilitation with Post stroke Motor Recovery

Despite improvements in acute care, stroke continues to be a leading cause of disability globally. Stroke affects a number of neurological processes, the most prevalent of which is motor impairment on the side not affected by the stroke. To help stroke patients regain their compromised mobility, several rehabilitation strategies based on motor learning paradigms have been developed[11].

The central nervous system's structure and/or function may change due to neural plasticity. Recent technological developments that enable noninvasive brain investigation have improved our knowledge of neuronal plasticity and how it relates to stroke recovery. Based on fundamental research and clinical studies describing brain remodelling caused by neural plasticity, several innovative stroke rehabilitation techniques for motor recovery have been created. Systematic reviews and meta-analyses have supported the efficacy of these strategies. However, since the processes underlying motor recovery differ across individuals, responses to rehabilitative therapies show significant inter-individual heterogeneity. Furthermore, these systems rely on a mix of spontaneous and learning-dependent processes to carry out complicated activities including restoration, substitution, and compensation. Therefore, understanding the processes behind motor recovery may aid in determining the best kind, length, and objectives of individual stroke rehabilitation treatments. Recent developments in neurophysiological and neuroimaging methods have helped us better understand and anticipate the efficacy of various stroke rehabilitation strategies by evaluating the variety of motor recovery processes[12].

In this overview, we first go over the fundamentals of task-specific training and enriched settings for stroke recovery. Then, we concentrate on cutting-edge stroke rehabilitation techniques that are backed by data on related brain plasticity. These techniques include body weight-supported treadmill training (BWSTT), robotic training, noninvasive brain stimulation (NIBS), action observation, constraint-induced movement therapy (CIMT), virtual reality (VR) training, and brain-computer interface (BCI). Finally, we go through individualised approaches that might help in defining therapy objectives, preventing maladaptive plasticity, and maximising functional recovery in stroke patients.

Principles of Stroke Rehabilitation

The majority of stroke rehabilitation procedures are focused on motor learning, which causes dendritic sprouting, the development of new synapses, changes to existing synapses, and the release of neurochemicals. These modifications are believed to provide a mechanistic foundation for stroke-related motor recovery. It is well recognised that meaningful, repeated, and intense practise methods enhance motor learning. Furthermore, stroke care facilities where multidisciplinary teams can promote active patient engagement are where stroke rehabilitation is advised to be used. In this part, we examine treatment strategies that encourage neuronal plasticity, such as task-specific training and enriched environments[13].

Task-Specific Training

Following a stroke, motor training should be aimed towards objectives that are pertinent to the patient's functional requirements. Therefore, a well-accepted tenet of stroke rehabilitation focuses on task-specific training to improve activities of daily living or other pertinent motor tasks. Numerous terminology, such as repeated task practise, repetitive functional task practise, and task-oriented treatment, have been used to characterise this method. In order to enhance each person's functional skills, task-specific training emphasises the repeated practise of competent motor performance. A broad range of motor behaviours including the upper limbs, lower limbs, sit-to-stand motions, and gait may be successfully recovered after stroke with task-specific training. Furthermore, it has been shown that repeated task-specific training produces greater functional improvements than nonrepetitive training.

There is mounting evidence that task-specific training makes use of brain plasticity. According to a meta-analysis of neurophysiological and neuroimaging studies, task-specific training induces long-lasting motor learning and associated cortical reorganisation, in contrast to conventional stroke rehabilitation approaches like simple motor exercises. These neural changes in the sensorimotor cortex of the affected hemisphere are reported to go hand in hand with the improvements in functional paretic upper extremity movements. Task-specific training may thus help with functional motor recovery, which is fueled by adaptive brain plasticity, since there is good evidence to support this claim[14].

Enriched Environment

The therapeutic environment is crucial to stroke recovery in addition to task specificity. Enriched surroundings are those that provide higher opportunities for physical exercise and motivation. Studies on animals using rat models of stroke have shown that enriched habitats, which provide more possibilities for play, social contact, and physical exercise than conventional laboratory cages, enhance motor recovery and brain plasticity[15]. Clinically, treatment delivered in a stroke unit (SU) by a well-coordinated multidisciplinary team may provide a rich environment for stroke patients.

Through a cyclical procedure that includes the essential components of evaluation, goal setting, intervention, and reassessment, SU care offers a structured package of treatment. Additionally, SU care gives people a clear idea of what is expected of them during task-specific training, leading to brain plasticity that enhances performance. It has been shown that patient involvement in patient-centered multidisciplinary goal planning increases their motivation and participation in treatment, leading to improved rehabilitation results for stroke patients with limited mobility. Numerous studies have shown that SU treatment has the highest beneficial effect on stroke-related impairment levels. The stated advantages of SU treatment also apply to patients of all ages and with all degrees of stroke severity. Therefore, to encourage brain plasticity and motor and functional recovery after stroke, stroke rehabilitation programmes should include meaningful, repeated, intense, and task-specific movement training in an enriched environment.

Novel Strategies Based on Motor Training

Numerous research conducted over the last several decades have shown the use of cutting-edge motor learning-based stroke rehabilitation techniques. We examine a number of typical neurorehabilitation techniques in this section on neuronal plasticity, including CIMT, BWSTT, and robot training[16].

CIMT

Stroke patients often carry out everyday tasks using the nonparetic limb rather than the paretic leg. The phenomenon of learnt nonuse in the paretic limb is brought on by dominant use of the nonparetic limb, which reduces the potential for further improvements in motor performance. A therapy approach called CIMT was created to combat the learned nonuse of the paretic limb. The nonparetic arm is physically restricted with a sling or glove, forcing the patient to undertake functionally focused tasks while using the paretic arm. According to a possible mechanism, CIMT's recurrent training of the paretic arm and limitation of the nonparetic upper arm may both be crucial for fostering brain plasticity.

In animal models of stroke, skill acquisition with the nonparetic limb has been shown to have a detrimental effect on the use-dependent plasticity of the afflicted hemisphere. Although the causes of this restriction are yet unknown, this phenomena could be caused by changes in interhemispheric connection that are use-dependent. Therefore, constraining the nonparetic limb may help to lessen the effects of stroke on the use-dependent plasticity of the paretic limb. Numerous studies have shown brain plasticity after CIMT using neuroimaging and neurophysiological methods. Previous research utilising transcranial magnetic stimulation (TMS) discovered that following treatment, the paretic hand's cortical representation size increased. Studies on brain imaging have shown that CIMT results in altered neural network activity. Furthermore, when compared to control treatment, a structural magnetic resonance imaging (MRI) investigation revealed that CIMT enhanced grey matter in the bilateral sensorimotor cortices. There is evidence that CIMT causes structural and physiological changes in stroke victims' brains[17].

The Extremity Constraint-Induced Therapy Evaluation experiment was a multicenter single-blind randomised controlled experiment that compared the effects of 2-week CIMT with standard care in 222 patients between 3-9 months following their first stroke. The CIMT group scored better on functional activities involving the paretic upper limb at the one-year mark. Furthermore, there was no drop from the 1-year evaluation at the 2-year follow-up, and the second-year trends for strength development were positive. The majority of CIMT evaluations also note trends in individuals with chronic stroke towards improved motor recovery. For individuals with an acute stroke, recent trials found no significant differences in motor recovery between CIMT and an equivalent dosage of conventional treatment. It's possible that little or no learnt nonuse during the acute period is to blame for this. Furthermore, compared to low-intensity CIMT, high-intensity CIMT produces less improvement in the acute stage of stroke. Therefore, further research is required to determine the best CIMT timing and intensity for motor recovery after a stroke[18].

BWSTT

BWSTT is a rehabilitation technique in which stroke victims walk on a treadmill while having some of their body weight supported. BWSTT makes it possible to repeatedly practise complicated gait cycles, which improves one's ability to walk. Hemiparesis may lead to aberrant control of the paretic lower leg in individuals who have had a stroke, resulting in an asymmetrical gait pattern. During the loading phase of walking, the trunk and knee alignment are straighter as a consequence of the body weight support system partially unloading the lower extremities. BWSTT also enhances walking speed, stride length, and swing time asymmetry. As a result, BWSTT enables the patient to walk in a virtually normal manner and prevents the development of compensatory walking behaviours like hip hiking and circumduction[19].

In patients with acute stroke and those who have had chronic stroke, there is evidence that gait improves with BWSTT, including the use of robotic device systems, compared to traditional treatment. However, regardless of whether BWSTT was begun 2 or 6 months after the stroke, a recent research found that the advantages of BWSTT were not better to those obtained with home-based physical therapy that focused on strength and balance. Additionally, numerous falls were more frequent in the group that got early BWSTT than in the group that received late BWSTT and physical therapy among patients with severe walking impairments. Therefore, balancing training that aids in preventing falls in patients, particularly those with acute stroke and severe disability, should be a part of BWSTT programmes.

BWSTT is thought to boost brain activity in the caudate nuclei, thalamus, cingulate motor regions, and bilateral primary sensorimotor cortices of the afflicted hemisphere. Additionally, BWSTT has been shown in animal experiments to modify central pattern generator activity. Patients who have had a stroke have compromised spinal cord function but intact cerebral cortex function. However, due to alterations in signals received as a result of brain reorganisation, spinal cord modifications may also be crucial for gait recovery after a stroke. Thus, BWSTT may be used to stroke patients to enhance walking speed, decrease asymmetries in gait parameters, and promote reorganisation at the spinal and supraspinal levels. Animal studies are the only ones that provide proof that this process involves brain plasticity[20].

Robot Training

With its high repeatability, precisely adjustable aid or resistance during movements, and objective and verifiable evaluations of subject performance, robotic training may be beneficial in stroke recovery. Robot training can also provide the rigorous, task-focused instruction that has been shown to be beneficial for fostering motor learning. These aspects of robot training are deemed advantageous for stroke survivors' motor rehabilitation.

Robot training treatments with mechanical assistance have been developed in recent years to enhance arm function in stroke recovery. Although there was no difference in motor recovery between rigorous physiotherapy and robot-assisted rehabilitative therapy, a multicenter, randomised controlled study of patients with chronic stroke and moderate-to-severe upper-limb disability did find that the treatment was more effective. Furthermore, comprehensive reviews and meta-analyses have not shown any significant improvements in daily living skills after robotic training. To aid in lower limb rehabilitation, automated electromechanical gait devices have also been created. Either a robot-driven exoskeleton orthosis or two electromechanical footplates that imitate gait phases make up these devices. These devices are advantageous because they eliminate the need for therapists to manage weight shift and establish the paretic limbs, as is necessary for treadmill training. The likelihood of resuming independent walking after a stroke rises with the use of electromechanically assisted gait-training devices combined with physical treatment, although walking speed is unaffected. As a result, it is crucial for robotic assistance to be performed with a minimal variation in input-output time employing electromyography (EMG) and/or position feedback in addition to automated repeated motor training. Because synchronisation between sensory and motor information promotes brain development, lowering these lag periods is crucial. Future research is required to discover the ideal subject features and whether robot training is superior to traditional treatment[21].

Conclusion

After a stroke, several methods and tools have been created to help people restore motor function in their upper and lower limbs. Robots are being employed more and more often in the field of rehabilitation, despite it being a vast one. As previously noted, patients must take advantage of a window of exponential recovery. This period of recovery may occur within the first three months after an episode and progressively shorten after six months following the stroke, according to some research. At this point, a significant amount of strength, range of motion, and mobility may be restored. Therefore, it is crucial that patients exercise often throughout this period in order to restore motor control. According to several studies, robot aided rehabilitation is a successful kind of therapy that eventually enables a patient to restore a significant amount of motor control. It has also been shown that adding robot-assisted workouts to routine treatment helps stroke patients become more independent overall. Robotic technologies can meet the need for more effective treatment options as stroke rates rise and the population expands quickly. The cost-effective feature can also make it possible for those who lack the funds to hire a therapist to get therapy. Although the outcomes of robot aided treatment are encouraging, further study is still required. Robotic devices have just recently been used to help patients gain better motor control, therefore other methods need to be tried. What can be agreed upon is that robot aided therapy has the potential to become the greatest form of care for a range of neurological ailments, not only stroke sufferers.

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