VIMS Journal of Physical Therapy

[REVIEW ARTICLE]

Recent Advances for Upper Extremity Rehabilitation in Acute and Subacute Post Stroke Survivors: A Narrative Review

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ABSTRACT

Background: Post-stroke survivors experience motor impairments and poor arm recovery, necessitating early rehabilitation. Robot-assisted therapy is being explored for improved outcomes, but is not feasible for all clinics. So, this review aims at different effective UE rehabilitation interventions.

Methodology: This study aimed to identify relevant articles on UE, acute and subacute stroke & Rehabilitation using search engines- Google Scholar, PubMed, Scihub from year 2019-2023 focusing on published articles in indexed journals, English language, and UL rehabilitation among acute and subacute stroke patients.

Result: Eleven studies, including 10 randomized control trials and 1 systematic review, found that various techniques like Robotics Assisted Therapy, CIMT, EMG biofeedback, and Mirror therapy improved motor control, functional independence, and muscle tone.

Conclusion: Limited resources in rehabilitation centers and clinics hinder intensive treatment, reducing stroke patients' recovery. Other techniques may improve functional independence, muscle tone, and quality of life.

Keywords: *Stroke, acute, subacute, upper extremity, Early rehabilitation.*

Introduction

Stroke (cerebrovascular accident [CVA]) is the sudden loss of neurological function caused by an interruption of the blood flow to the brain. Two types of brain stroke are hemorrhagic and ischemic. Hemorrhagic stroke, which is due to blood vessel rupture, accounts for 20% of CVAs. Ischemic stroke due to brain vessels occlusion and blockage includes 80% .

The Stroke Roundtable Consortium proposed to designate the first 24 h as the hyperacute phase, the first 7 days as the acute phase, the first 3 months as the early sub-acute phase, the months 4–6 as the late sub-acute phase, and from 6 months on as the chronic phase. This distinction is made because post-stroke mechanisms associated to recovery are time-dependent. A cascade of plasticity-enhancing mechanisms starts to take effect just hours after brain ischemia begins, causing dendritic expansion, axonal sprouting, and the development of new synapses.

Additionally, the most significant changes occur in the first few weeks following a stroke, frequently reaching a relative plateau after three months and then recovering less significantly, especially in terms of motor symptoms, After six months, spontaneous recovery typically reaches its limit and results in a deficit that is more or less constant, or chronic.

Many people with stroke will have significant sensorimotor impairments and disabilities in the upper extremity (UE) and lower extremity (LE) . In the majority of stroke patients, the upper limb is more severely involved than the lower limb . Paresis, altered muscle tone, diminished somatosensation, and coordination are the most frequently seen in upper limb deficits and due to which basic tasks like opening doors, handling keys, or using computers and other ADL activities becomes more difficult as a result of such impairments.

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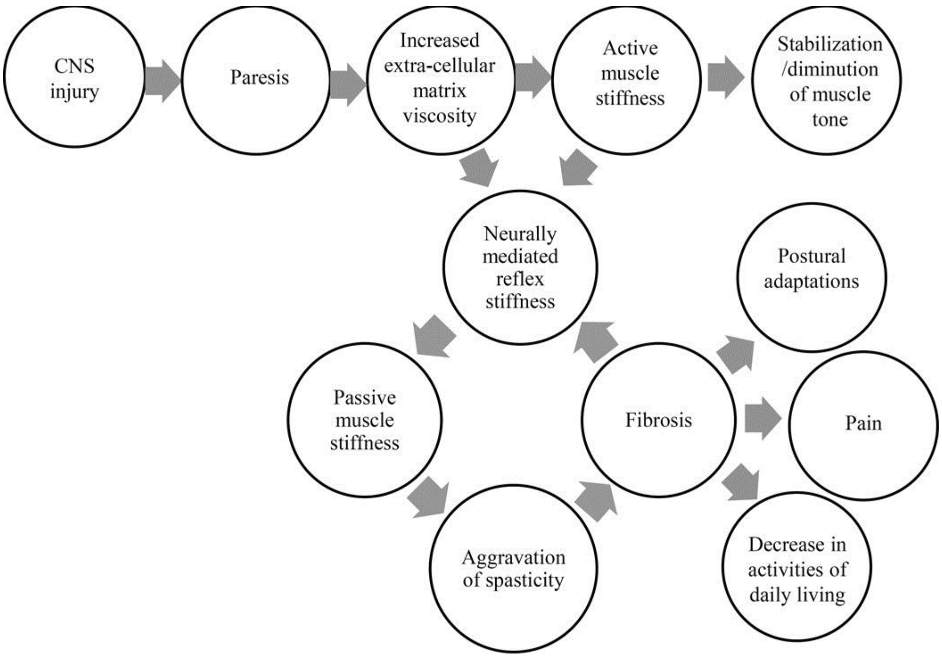

Fig. 1: Model of the contribution of paresis and immobility to the evolution of spasticity

Limitations in daily living activities are greatly influenced by the altered upper limb function and loss of dexterity, which can also affect social reintegration and return to work. The majority of fine movements in daily activities are performed with the hands, and impairment in hand function have a significant impact on the accuracy with which various daily tasks are performed. Therefore, restoring arm function through reducing disability and enhancing arm abilities is a crucial goal in rehabilitation during the initial stage of a stroke and in ongoing treatment.

UE rehabilitation currently uses a variety of modern assistive technology. The use of new technology has a positive effect on functional and motor recovery after post-stroke therapy. For stroke rehabilitation, new therapeutic modalities have been researched, such as non-invasive brain stimulation, functional electrical stimulation, robotic therapies, EMG biofeedback, brain computer interface, constraint-induced movement therapy, mirror therapy, and virtual reality (VR).

Fig. 2: Different modern assistive technology for UE rehabilitation

The purpose of this review was to find effective rehabilitation intervention which can be cost friendly and easily used for upper extremity recovery and provides an opportunity to achieve a desirable effect primarily aimed at restoring and maintaining activities of daily living (ADL) for acute and subacute stroke patient.

Materials And Methods

Literature and study design

Present research focused on recent advancements in upper limb rehabilitation in post stroke survivors. The data were published between 2019 to 2023. Literature was researched using various search engines, including Google Scholar, Scihub, and Pubmed. The keywords were used (1) Recent advances rehabilitation (2) Upper extremity (3) Acute and subacute stroke. The search was conducted by integrating all the selected keywords from the databases listed above.

Selection criteria

Inclusion criteria for our narrative review were- (1) Studies which have full text available 2) studies in English language (3) Study that include acute /subacute stroke (4) Study that include upper limb rehabilitation (5) Studies that rated at a score of 7 or higher according to the PEDRO scale

Result

Study Selection

60 articles were obtained from the search strategy and following the inclusion criteria 50 studies were excluded. Thus, total 10 studies qualified in our criteria.

Study characteristics

Total 11 different studies were selected in this narrative review in which 10 randomized control trials and 1 systemic review were there which described different upper extremity rehabilitation in acute and subacute stroke patients as shown in table 1

	Title/author	Study design	Intervention	Outcome	Conclusion
1	Comparative Effects Of EMG-Driven Robot-Assisted Therapy Versus Task - Oriented Training On Motor And Daily Function In Patients With Stroke: A Randomized Cross-Over Trial Yen-Wei Chen (2022)	Randomized control trial(RCT) n=31	• Robot-assisted intervention group • Task oriented group 12 sessions	• Fugl-Meyer Assessment for Upper Extremity • Wolf Motor Function Test • Action Research Arm Test ¾ Motor Activity Log.	• EMG-driven robot-assisted therapy is as effective as task-oriented training in activity domain • While EMG-driven robot-assisted therapy is not as effective as task-oriented training in body function domain and participation domain.
2	A Comparative Efficacy Study Of Robotic Priming Of Bilateral Approach In Stroke Rehabilitation Yi-Chun Li (2021)	Randomized control trial (RCT) n=31	• Robotic priming combined with MT • Robotic priming combined with BULT 6 weeks 45 mins/day	• Fugl–Meyer Assessment (FMA), • Chedoke Arm and Hand Activity Inventory (CAHAI) • Accelerometer data.	• Robotic priming combined with MT may have beneficial effects for patients in the improvements of overall and distal arm motor impairment as well as affected arm use in real life

3	Clinical Effects Of Immersive Multimodal BCI-VR Training After Bilateral Neuromodulation With Rtms On Upper Limb Motor Recovery After Stroke :A Study Protocol For A Randomized Controlled Trial Francisco José Sánchez-Cuesta (2021)	Randomized Controlled Trial (RCT) n-=42	• Conventional rehabilitation + bilateral rTMS + Immersive multimodal BCI-VR training system NeuRow • Conventional rehabilitation + bilateral rtms	• Motricity Index of the Arm (MI) • Fugl-Meyer for upper limb (FMA-UE) • Stroke Impact Scale (SIS)	• Additive value of VR immersive motor imagery as an adjuvant therapy combined with a known effective neuromodulation approach opening new perspectives for clinical rehabilitation protocols
4	Sequentially Applied Myoelectrically Controlled FES In A Task-Oriented Approach And Robotic Therapy For The Recovery Of Upper Limb In Post-Stroke Patients: A Randomized Controlled Pilot Study Gloria Perini,(2021)	Randomized Controlled Trial(RCT) n=18	• Sequentially applied MeCFES in a task-oriented approach and robotic therapy • Conventional therapy 20 Sessions 45 mins /day	• Fugl-Meyer upper extremity (FMA-UE) • Reaching Performance Scale • Box and Block Test	• Combination of MeCFES and robotic treatment may be more effective than standard care for recovery of the hemiplegic arm in persons after stroke.
5	Neuromuscular Electrical Stimulation Improves Activities of Daily Living Post Stroke: A Systematic Review and Metaanalysis Malene Glavind Holmsted Kristensen (2021)	Systematic Review and Meta-analysis Articles included =20	• Study with control and intervention groups	• Primary outcome - activities of daily living (ADL) • Secondary outcome - functional motor ability post stroke	• A significant positive effect of NMES toward ADL function in the poststroke rehabilitation process • Subgroup analysis indicated that NMES application in the subacute stage is efficacious for ADL rehabilitation and functional motor abilities.
6	Effect Of Modified Constraint Induced Movement Therapy On Fatigue And Motor Performance In Sub Acute Stroke Wassim Mushtaq (2020)	Randomized Controlled Trial(RCT) n=20	• Experimental group (CIMT) • Control group 5 times a week for 3 week 2 hour/day	• Wolf Motor Function Test Scores (WMFT)	• Restraint improves motor performance in subacute therapy group and the intensive practice

					associated with m-CIMT may be administered without the exacerbation of fatigue.
7	Effect And Safety Of Transcutaneous Auricular Vagus Nerve Stimulation On Recovery Of Upper Limb Motor Function In Subacute Ischemic Stroke Patients: A Randomized Pilot Study Dandong Wu (2020)	A Randomized Pilot Study n=21	• taVNS group • Sham taVNS group 15 consecutive days 30min/day	• Fugl-Meyer assessment (FMA-U) • Wolf motor function test (WMFT) • Functional Independence Measurement (FIM) • Brunnstrom stage	• taVNS appeared to be beneficial to the recovery of upper limb motor function in subacute ischemia stroke patients without obvious adverse effects.
8	Effectiveness Of Upper-Limb Robotic-Assisted Therapy In The Early Rehabilitation Phase After Stroke : A Single-Blind,Randomized , Controlled Trial Stéphanie Dehem (2019)	Randomized Controlled Trial(RCT) n=45	• Robot assisted therapy group (RAT) • Control group 4 sessions / week 45min/day	• FMA-UE • BBT (blocks/min) • S-WMFT FAS • ABILHAND • Stroke impact scale	• RAT combined with conventional therapy during the early rehabilitation phase after stroke is more effective than conventional.
9	Influence Of New Technologies On Post-Stroke Rehabilitation: A Comparison Of Armeo Spring To The Kinect System Ausra Adomaviciene(2019)	Randomized Controlled Trial(RCT) n=42	• Armeo Spring robot-assisted trainings Group • Virtual reality Kinect-based system trainings Group 45 mins/day 10 Sessions	• FMA-UE (Fugl–Meyer Assessment Upper Extremity • Modified Ashworth Scale • Box and Block test • Kinematic measures (active Range of Motion (ROM)	• Had a positive effect and significantly recovered functional level in • Self-care, dexterity and movements, grip strength, kinematic data), • Visual constructive abilities (attention, memory, • Visuo-spatial abilities

10	Comparison Between Movement-Based and Task-Based Mirror Therapies On Improving Upper Limb Functions In Patients With Stroke: A Randomized Controlled Trial Zhongfei Bai (2019)	Randomized control study (RCT) n=34	• Movement-based mirror therapy (MMT)group • Task-based mirror therapy (TMT) group • Control group	• Fugl-Meyer Assessment-upper extremity (FMA-UE) • Wolf Motor Function Test (WMFT) • Modified Ashworth scale (MAS) • Modified Barthel index (MBI).	• Both MMT and TMT are effective in improving the upper limb function of patients with mild to moderate hemiplegia due to stroke. • MMT seems to be superior to TMT in improving hemiplegic upper extremity impairment.
11	A Randomized Control Trial Comparing the Effects of Motor Relearning Programme And Mirror Therapy For Improving Upper Limb Motor Functions In Stroke Patients Shafqatullah Jan (2019)	Randomized control study (RCT) n=66	• Motor Relearning Programme Group • Mirror therapy group 6 weeks 2 hours /day	• Upper limb (UL) sub-scales of motor assessment scale • Upper arm functions • Hand movements and advanced hand activities	• Motor Relearning Programme and Mirror therapy were found to be effective in improving upper limb motor functions of stroke patient

Discussion

Total of 11 studies were done in which different novel approaches of neuro-rehabilitation and which one is better or more applicable was studied and it showed that certain interventions were highly effective and some were equally effective.

Constraint-induced movement therapy used for upper extremity rehabilitation after stroke enhanced upper extremity movement and function . Robot-assisted upper extremity training could improve upper extremity function, upper extremity muscle strength, and the quality of life without increasing the additional risk. Thieme et al. found that mirror therapy, a method that let the patient believe the affected extremity moved like the unaffected extremity, was able to increase upper extremity motor function and decrease the pain. Non-invasive brain stimulation (NIBS) by repetitively activating circumscribed brain regions with magnetic stimulation has a promising future as an augmentative therapeutic approach to traditional physical therapy after stroke.

Recent evidence has established that neuromuscular electrical stimulation improved the Fugl-Meyer scale and MAS scores, meanwhile, the positive effects were retained for six months. EMG-driven robot-assisted therapy and task-oriented training were effective in improving upper extremity function in patients with stroke, and each intervention protocol had its own advantages in different domains. Robot-assisted intervention showed better improvement in activity domain, especially in performance time, and task-oriented intervention showed better improvement in body function domain.

taVNS appeared to be beneficial to the recovery of upper limb motor function in subacute ischemia stroke patients and without obvious adverse effects. NMES had a significant effect for improving functional motor abilities in patients with severe paresis, whereas treatment of moderate paresis was insignificant. This study focused to give a concise overview to help healthcare practitioners working in acute and subacute stroke settings with patients who have post-stroke UL limitations and determine the most effective therapeutic options.

Conclusion

Limited resources at rehabilitation centers and clinics prevent patients from receiving intensive treatment and extensive attention, frequently reducing the degree up to which they recover.

So, any of the recent technique with available resources may be effective and give significant result according to the severity in patients with stroke to improve functional independence, muscle tone and quality of life.

Limitation of the Study

Due to time constraints, the search strategy may not review many studies, resulting in a limited overview.

Further Scope of the Study

The study on UE rehabilitation in post-stroke survivors could expand to include the chronic phase of recovery, comparing emerging technologies and traditional methods, integrating multidisciplinary strategies, and investigating neuroplasticity-enhancing interventions. Assessing the cost-effectiveness and accessibility of advanced rehabilitation technologies, especially in resource-limited settings, and involving patients and caregivers in home-based programs could improve long-term recovery outcomes.

Acknowledgement

None

Conflict of Interest

None

Source of Funding

None

References

1. Susan B. O'Sullivan, Thomas J. Schmitz, George D. Fulk . Physical Rehabilitation 6th ed. 2014. p. 645
2. Bernhardt J, Hayward KS, Kwakkel G, Ward NS, Wolf SL. Agreed definitions and a shared vision for new standards in stroke recovery research: the stroke recovery and rehabilitation roundtable task force. International Journal of Stroke. 2017 Jul;12(5): 444-50.
3. Carmichael ST, Wei L, Rovainen CM, Woolsey TA. New patterns of intracortical projections after focal cortical stroke. Neurobiology of disease. 2001 Oct 1;8(5):910-22.
4. Kitagawa K. CREB and cAMP response element-mediated gene expression in the ischemic brain. The FEBS journal. 2007 Jul;274(13):3210-7.
5. Kwakkel G, Kollen BJ, van der Grond J, Prevo AJ. Probability of regaining dexterity in the flaccid upper limb: impact of severity of paresis and time since onset in acute stroke. Stroke. 2003 Sep 1;34(9):2181-6.
6. Nishimura Y, Onoe H, Morichika Y, Perfiliev S, Tsukada H, Isa T. Time-dependent central compensatory mechanisms of finger dexterity after spinal cord injury. Science. 2007 Nov 16;318(5853):1150-5.
7. Cramer SC. Repairing the human brain after stroke: I. Mechanisms of spontaneous recovery. Annals of neurology. 2008 Mar;63(3):272-87.
8. Desrosiers J, Malouin F, Richards C, Bourbonnais D, Rochette A, Bravo G. Comparison of changes in upper and lower extremity impairments and disabilities after stroke. International Journal of Rehabilitation Research. 2003 Jun 1;26(2):109-16
9. Shelton FD, Reding MJ. Effect of lesion location on upper limb motor recovery after stroke. Stroke. 2001 Jan;32(1):107-12.
10. Hussain N, Alt Murphy M, Sunnerhagen KS. Upper limb kinematics in stroke and healthy controls using target-to-target task in virtual reality. Frontiers in neurology. 2018 May 9;9:300.
11. Penta M, Tesio L, Arnould C, Zancan A, Thonnard JL. The ABILHAND questionnaire as a measure of manual ability in chronic stroke patients: Rasch-based validation and relationship to upper limb impairment. Stroke. 2001 Jul;32(7):1627-34.
12. Lai SM, Studenski S, Duncan PW, Perera S. Persisting consequences of stroke measured by the Stroke Impact Scale. Stroke. 2002 Jul 1;33(7):1840-4.
13. Perini G, Bertoni R, Thorsen R, Carpinella I, Lencioni T, Ferrarin M. Sequentially applied myoelectrically controlled FES in a task-oriented approach and robotic therapy for the recovery of upper limb in post-stroke patients: A randomized controlled pilot study. Technology and Health Care. 2021 Jan 1;29(3):419-29.

14. Langhorne P, Bernhardt J, Kwakkel G. Stroke rehabilitation. The Lancet. 2011 May 14;377 (9778):1693-702.

15. Kwakkel G, Veerbeek JM, van Wegen EE, Wolf SL. Constraint-induced movement therapy after stroke. The Lancet Neurology. 2015 Feb 1;14(2):224-34.

16. Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane database of systematic reviews. 2018(9).

17. Thieme H, Morkisch N, Mehrholz J, Pohl M, Behrens J, Borgetto B. Mirror therapy for improving motor function after stroke: Update of a Cochrane review. Stroke. 2019