OPEN ACCESS

SYSTEMATIC REVIEW Volume 14 (Issue 2), 2025 | Page No. 07-19

Effects of Telerehabilitation versus Supervised Clinical Rehabilitation in Stroke Patients for Recovery of Motor Function: A Systematic Review

Atif Ahmed Khan[1], Bisma Hakeem*[2], Hafsa Rafiq[2], Ali Abid[3], Muhammad Hanzalah Atif[4]

[1]Surg Cdr (Lt Col), Head of Department, Rehabilitation Medicine Department, PNS Shifa Hospital,
[2]House Officer, PNS Shifa Hospital,
[3]Physical Therapist, Rehabilitation Medicine Department PNS Shifa Hospital
[4]Student, Dow University of Health Sciences

ABSTRACT

Background of the study: Telerehabilitation, which involves delivering physical, occupational, speech, and other therapies under remote supervision, represents a potential approach to addressing motor, cognitive, and neuropsychiatric problems in stroke survivors. This systematic review aimed to determine the effects of supervised clinical rehabilitation and telerehabilitation on stroke patients' ability to recover motor function.

Methodology: A comprehensive search was conducted from July 2014 to July 2024 across multiple databases including Google Scholar, PubMed, PEDro, CINAHL, and Cochrane Library using keywords related to stroke and telerehabilitation. Studies examining stroke survivors receiving physiotherapy in clinical settings or through telerehabilitation were assessed for motor function outcomes. Inclusion criteria comprised randomized controlled trials evaluating different interventions for motor function recovery. Eleven publications provided data for the study, and the Cochrane risk of bias assessment tool was used to evaluate article quality.

Results: Study results showed no significant differences between the intervention group (receiving telerehabilitation) and control group (receiving clinical interventions) across all motor function outcomes, including fine and gross motor skills, functional mobility, and fine dexterity. However, significantly higher patient satisfaction was observed in the telerehabilitation group.

Conclusion: Results demonstrate that telerehabilitation effectively improves motor function in stroke patients as an alternative to in-person rehabilitation. Telerehabilitation successfully overcomes access barriers for long-term rehabilitation, leading to better recovery outcomes and enhanced patient satisfaction.

Keywords: *Digital, Motor function, Stroke, Telerehabilitation, Virtual reality.*

INTRODUCTION

Stroke survivors experience long-term physical, cognitive, and somatosensory impairments resulting from stroke, cerebral infarction, or brain hemorrhage[1]. Stroke is characterized by rapid onset of cerebral blood circulation disruption, rapid development, and multiple consequences[2].

***Corresponding Author:** Bisma Hakeem
Email: bismahakeem997@gmail.com

Citation: Khan AA, Hakeem B, Rafiq H, Abid A, Atif MH. Effects of Telerehabilitation versus Supervised Clinical Rehabilitation in Stroke Patients for Recovery of Motor Function: A Systematic Review. Pakistan Journal of Rehabilitation. 2025 Jul 07;14(2):007-19. Available from: https://doi.org/10.36283/pjr.zu.14.2/003.

Received: Fri, March 14, 2025 **Accepted:** Wed, Jun 30, 2025 **Published:** Mon, July 7, 2025

It is considered the fourth most prevalent cause of lost productivity and the second most common preventable cause of death globally. According to World Health Organization estimates, strokes caused 5.7 million deaths and 16 million disabilities. By 2030, these figures are expected to rise to 7.8 million and 23 million, respectively[3].

After a stroke, only a small percentage of people achieve full functional recovery, while the majority experience difficulty performing activities of daily living (ADLs), including social interaction and self-care[4]. Therefore, early and efficient targeted therapy for stroke patients after onset is crucial for preventing complications and improving patient prognosis[5]. Early, intensive, and ongoing treatments are necessary to achieve functional and healthy outcomes. Rehabilitation should begin as soon as possible following a neurological illness diagnosis and continue for a considerable period after discharge[6].

Many patients are denied treatment after discharge due to their inability to access rehabilitation facilities because of transportation issues, financial constraints, and other barriers. In this context, telerehabilitation is the most commonly utilized approach for providing rehabilitation services to patients[7]. Telerehabilitation refers to the provision of rehabilitation services using telemedicine through information and communication technologies, including computers, mobile phones, robotic devices, video/teleconferencing, remote data-collection equipment, telemonitoring, exergames, and virtual reality (VR)[8]. The rationale for this systematic review was to compare telerehabilitation with in-clinic stroke rehabilitation therapy models across several outcomes, including motor function and activities of daily living[9].

Rapid advancements in information technology now enable stroke survivors to continue their therapy after leaving the hospital. Telerehabilitation, also known as remote stroke rehabilitation, provides stroke survivors and medical professionals with various care settings for ongoing therapy and monitoring[10]. Telerehabilitation has been recognized as advantageous compared to traditional training at medical facilities due to its convenience and ability to overcome socioeconomic, geographic, and cultural barriers[11]. Additional benefits of telerehabilitation for stroke patients include delivering services to remote locations for individuals who cannot otherwise receive them and providing more in-person support following treatment[12].

Over the past few years, telerehabilitation technologies have evolved, ranging from synchronous approaches (such as videoconferencing) to asynchronous methods (such as messaging or data gathering) for remote monitoring and programs on various digital platforms[13]. Telesupervision combined with digital rehabilitation enables comprehensive monitoring and individualized performance feedback for patients. It also provides opportunities to address persistent problems and overcome obstacles related to patient participation in digital training. The rise of digital home rehabilitation programs presents an opportunity to reconsider the role of therapists, with motor practice being self-managed at home while therapist time is devoted to remote supervision, monitoring, and feedback[14]. Another benefit is that digital rehabilitation programs allow for remote measurement of self-reported results, potentially reducing the number of necessary outpatient visits[15].

This review explores the effectiveness of rehabilitation services using different technologies delivered through telerehabilitation or in clinical settings, reports outcome measures of motor functions, and determines which type of rehabilitation service delivery system is beneficial for patients. The main goal of this review is to establish telerehabilitation as a long-term rehabilitation option for stroke survivors and provide guidance for designing and implementing patient-centric telerehabilitation services in outpatient and community settings.

METHODOLOGY

Design

This review was guided by the Cochrane Handbook for Systematic Reviews of Interventions and followed the Preferred Reporting Items for Systematic Reviews[16]. The review protocol was registered in the International Prospective Register of Systematic Reviews (PROSPERO) (CRD420251011133).

Search Strategy

The databases used to search for literature were: Google Scholar, PubMed, PEDro, CINAHL, and Cochrane Library. Only studies published from July 2014 to July 2024 were included. Experienced medical librarians helped create a comprehensive search strategy that included various search terms for stroke and rehabilitation services. The searches targeted trials of interventions that improve motor functions in stroke patients through telerehabilitation or supervised clinical rehabilitation. The comprehensive search strategy included keywords such as "Telerehabilitation" OR "Clinical rehabilitation" AND "Stroke" OR "digital rehabilitation" OR "internet" AND "eHealth". Additionally, RCT search syntaxes were used.

Study Selection

PRISMA guidelines were used for study selection. Primary research studies were randomized controlled trials (RCTs) published in English between July 2014 and July 2024. Rayyan was used as a screening tool. Duplicates were removed through Excel's duplication feature and manually. After separately examining abstracts and titles, two investigators (BH and HR) extracted data and independently checked the full text for eligibility. Both the initial and full-text screening procedures were pilot-tested and discussed before additional screening. When discrepancies occurred during the selection procedure, an external reviewer (AA) with expertise in the systematic review process (SK) made an unbiased and conclusive decision. The PRISMA flow diagram was used for the search strategy in this review.

Eligibility Criteria

Inclusion and exclusion criteria based on the PICOS format were used to identify studies:

The study population comprised stroke survivors aged >18 years with no exclusion based on stroke type. The pediatric population was excluded from the review due to the low ratio of stroke incidence in this population and the difficulty of delivering telerehabilitation services to this group. The study included populations with stroke at any stage and excluded studies where participants had other neurological conditions in addition to stroke. For inclusion, interventions should target rehabilitation programs focusing on motor functions, with delivery modes being telerehabilitation or in-clinic rehabilitation. Advanced technologies such as robotic technology and virtual reality delivered through telerehabilitation, and supervision technologies such as video conferencing, monitoring, and feedback to physiotherapists were included. All study designs were searched, but studies published in English and randomized controlled trials were considered feasible for the intervention of interest, as the aim was to assess treatment effects.

Data Extraction and Management

Two independent reviewers (BH and HR) used titles and abstracts of references found during searches to determine study qualification. After individually reading the full texts of pre-selected articles, two reviewers (AA and MHA) discussed and decided on the final collection of articles. The quality of included studies was evaluated by two reviewers (AA and MHA) using the Cochrane Risk of Bias assessment tool. Any discrepancies were resolved through discussion with

a third reviewer (AA). Study characteristics were provided, including participant gender and mean age, study type (e.g., RCT), duration (weeks), frequency (sessions/week), intervention intensity, and clinical outcome measures.

Methodological Quality Assessment

According to the Cochrane Handbook for Systematic Reviews of Interventions, the Cochrane Risk of Bias (RoB) 2 tool for Randomized Controlled Trials (RCTs) was used to assess bias risk. The program uses five domains to construct the overall risk of bias (RoB): randomization, allocation concealment, participant blinding, attrition bias, selection bias, and conflict of interest (Table-2).

RESULTS

A total of 581 records were found. 449 duplicate records were eliminated manually and through Excel's duplication feature. Eligibility was determined by screening titles and abstracts of remaining records. Ultimately, 11 papers that satisfied the inclusion criteria were included in the final synthesis (Table-1, Figure-1).

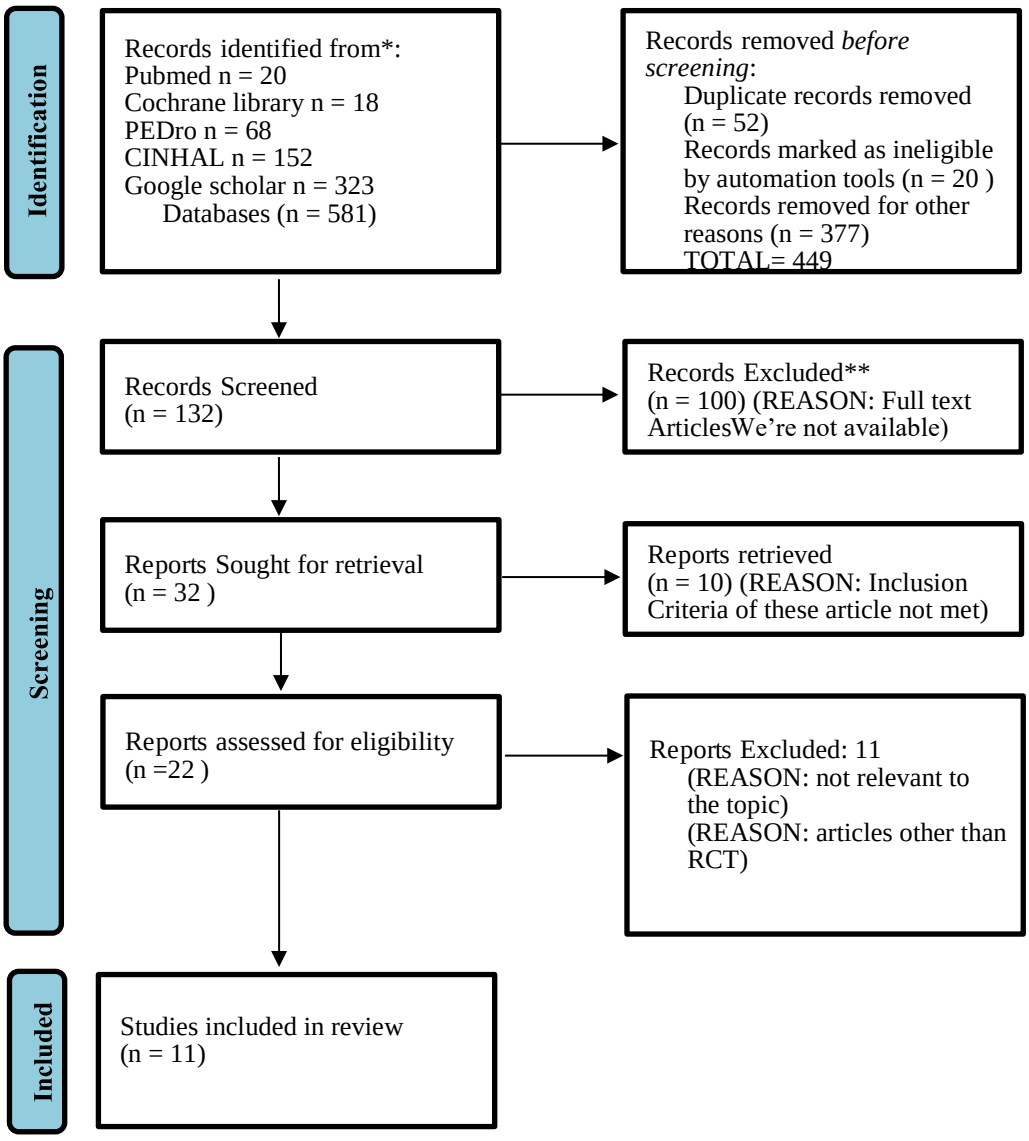

Figure-1 PRISMA Flow Chart

The population in motor rehabilitation trials ranged in age from 18 to 85 years, and interventions lasted at least 6 months. Of the 11 studies on motor impairments, three evaluated therapies specifically for stroke patients' upper extremity motor functions, two focused on interventions for neurological function recovery, and six evaluated interventions for motor function recovery. A wide range of interventions was included to provide a comprehensive overview and compare the effectiveness of interventions delivered through different pathways. For inclusion, interventions needed to include both remote delivery at home versus supervised clinical rehabilitation to compare effectiveness across delivery methods.

Interventions included constraint-induced movement therapy (CIMT) through telerehabilitation and in physiotherapy departments, supervised home-based self-rehabilitation programs, action observation added to standard virtual reality (VR), telerehabilitation with robotics (soft inflatable robotic gloves, cloud-connected software interfaces), Innovative Telerehabilitation Enhanced Care Programme (ITECP), and interventions based on telerehabilitation with digital and robotic tools. Virtual reality exergame training (VRET) and acupuncture combined with rehabilitation were also included. Interventions targeting other impairments such as speech and cognition were excluded. Overall, telerehabilitation was associated with improvements in motor function across the majority of primary and secondary endpoints in all examined trials.

Primary Outcomes

The main endpoints were motor functions, comprising muscular strength, gross and fine motor abilities, functional mobility, and fine dexterity, measured using various instruments and questionnaires. Primary outcomes were assessed using the Fugl-Meyer upper extremity motor assessment scale (FM-UE), Wolf Motor Function Test (WMFT), 9-Hole Peg Test (9-HPT), Motor Activity Log-28 (MAL), and Box and Block Test (BBT). Of the 11 reviewed articles, significant improvement in motor functions was found in 8 articles[17–24]. Among these, 5 studies showed significant improvement in both control and experimental groups, while 3 studies showed significant improvement in experimental groups receiving rehabilitation services through telerehabilitation. Results also demonstrated that patients receiving rehabilitation services through telerehabilitation showed significant improvement in motor function and reported the highest satisfaction with outcomes.

Secondary Outcomes

Secondary endpoints included improvements in activities of daily living and quality of life. ADLs were assessed using the Barthel Index (BI) and Functional Independence Measure (FIM). The ability to perform everyday tasks was evaluated using the Stroke Self-Efficacy Questionnaire (SSEQ). Of the 11 studies, 5 measured improvements in quality of life and ADLs[25–27,17,20]. Results from most studies favored telerehabilitation. Supervised clinical rehabilitation also showed improvements in quality of life and ADLs, but greater patient satisfaction was reported in the group receiving intervention through telerehabilitation in terms of recovery and feasibility of receiving rehabilitation services.

Table-1 Characteristics of Included Studies

Author	Target Population	Participants Characteristics	Telerehabilitation System/ Technology	Intervention Parameters	Outcome Measures	Findings
Shamweel et al., 2024	N=30	**INCLUSION CRITERIA:** participants aged between 35 and 75 years; At least 6 months post-stroke; minimum degrees of active shoulder, elbow and wrist movements; ability to transfer independently; mentally stable status and ability to follow commands **EXCLUSION CRITERIA:** inability to cooperate and follow commands; presence of any other neurological conditions in addition to stroke that could affect motor function	Google meeting (teleconferencing setup)	**GROUP A:** Exercise in physiotherapy department **GROUP B:** Exercise through telerehabilitation **FREQUENCY:** both groups perform three sessions per week with a duration of 40 minutes of exercise for 4 weeks; training each day wore a constraint mitt on the unaffected hand for 4 hours per day **INTERVENTIONS:** Shaping and task specific activities, AROM exercises, dynamic reaching activities, weight bearing activities for upper limb	Outcome was measured through different test scores that include FMA UE, WMFT Function, WMFT Time, MAL and QOM.	Significant difference ($p < 0.05$) between the pre-test and post-test evaluations within the group analysis. In group A, a significant increase in FMA-UE, WMFT and MAL was observed. Group B showed a significant increase in FMA-UE, WMFT, and MAL (AOU, QOM) scores. Both groups show significant improvement in all test score. Mean score of outcome revealed significant improvements in both groups.
Saygili et al., 2024	N=18	**INCLUSION CRITERIA:** Diagnosed for stroke 1 month ago; Able to move upper limb actively at least some degrees; Having score below 2.5 in MAL-28; Able to stand without assistance for at least 2 minutes **EXCLUSION CRITERIA:** Spasticity in any joint more than 2 according to MAS; Pain in UE that is greater than 4 according to VAS; Any disease that prevents participation in rehab program	Zoom or Skype applications that the patients would use for videoconference. Brochure was also given	**GROUP A:** perform basic exercises at home such as AROM, balance and walking. **FREQUENCY:** 5 days per week for 3 weeks **GROUP B:** Perform modified CIMT through telerehabilitation. **FREQUENCY:** 5 days per week for 3 weeks, 90 minute session for each day	Outcomes of the study were measured through STREAM, FM-UE, WMFT and P-HPT. Secondary outcomes were measured through grip strengths, pinch strengths, (MAL-28), and (FIM) scale.	Results of the study show that the UE motor functions, fine dexterity, and grip strength improved, increased, and thus the functional independence level of the individual in activities of daily life significantly improved with Tele-CIMT. Voluntary movement was evaluated through STREAM that shoe significant improvement in CIMT group but not in control group.
Rossetto et al., 2024	N=100	**INCLUSION CRITERIA:** 18-59 yr. old patients diagnosed with hemorrhagic stroke; Muscle grade 1-3 according to MMT; Vitally stable **EXCLUSION CRITERIA:** Having organ dysfunction or malignancy; Impaired consciousness or cognitive dysfunction	We chat groups are used for daily reminders and follow up	**GROUP 1:** Paper exercise rehabilitation was given to participant that includes photographs and demonstrator instructions. Patient performs these exercises at home. **FREQUENCY:** For 3 months **GROUP 2:** Exercise demonstrates through video and we chat group used for reminder and follow up. Participants were doing basic activities such as positioning, ROM, gait training and upper extremity rehabilitation exercises.	Outcomes were measured through different scales such as PAEAS, MAS, BI, ESES and SF 12.	Result of the study shows that home based rehabilitation is functional and cost effective whereas telerehab is adherent for patients and has better outcome than traditional stroke rehabilitation.
Jin et al., 2023	N=90	**INCLUSION CRITERIA:** Diagnosed with chronic post-stroke	camera and the speaker's microphones	**GROUP 1** Perform usual care exercises at home provide through digital booklet that	Outcomes were measured through 9-	Results show that both robot and Homing systems allow for controlled

		condition with ischemic or hemorrhagic stroke injury occurred 4-6 months before recruitment and with motor impairment of the upper limb >2 to the Medical Research Council scale (MRC); Age 25-85 yr.; Preserved cognitive level **EXCLUSION CRITERIA:** Any clinical instability; Any psychiatric or visual impairments		focuses on the repetitive practice of exercises aimed to mobilize and enhance motor control of upper limb functions, contributing to improved joint mobility, postural control, muscle recruitment, and fine hand mobility. **FREQUENCY:** 4 sessions per week for 5 weeks **GROUP 2:** Task oriented approach to improve motor functions. Rehabilitation was done through robot that manage interactive exercise activities **FREQUENCY:** 4 sessions per week for 5 weeks	HPT, FMA--UL and ARAT.	and customized task-oriented exercises based on the unique characteristics of each patient at home. Screens and visual/auditory feedback provides sensory input, promoting learning and engagement through the interactive nature of the technological device.
Kang et al., 2023	N=50	**INCLUSION CRITERIA:** Unilateral upper limb paresis; Movement ability of paretic upper limb controlled by medical research council index (>2 and <4) **EXCLUSION CRITERIA:** cognitive impairment, unilateral spatial neglect; visual deficit	Virtual reality technology	**GROUP 1:** Videos that depict naturalistic scenes **GROUP 2:** Treatment based on virtual reality watch bimanual actions that seen on monitor and repeat it for at least 3 consecutive times. Participants also wear kinematic sensor during exercise **FREQUENCY:** Minimum 16 and maximum 20 sessions within 5 weeks, 4 days per week.	Outcomes of the study were measured through BBT, MAS, morticity index and BI.	Significant improvement in both groups
Errante et al., 2022	N=120	**INCLUSION CRITERIA:** Participants in the research are evaluated based on whether they suffered an ischemic or hemorrhagic stroke. After recovering from a stroke in the hospital, they voluntarily choose to participate in the study. **EXCLUSION CRITERIA:** If a participant is presently in the hospital, unable to participate in physical activity due to neurological disorders (apart from stroke), orthopedic problems in their lower limbs, heart or lung issues, or is unable to complete the assigned challenge based on the evaluator's assessment, they will be disqualified from the trial.	Virtual reality exergame program (VRET)	For eight weeks, there will be twice-weekly, 60-minute sessions that include resistance and aerobic training in addition to functional training.	outcome measures of study was isokinetic muscle strength and grip strength, vo2 peak and 6 min walking test, short physical performance	Valuable insights into the efficacy of VRET as a therapeutic tool for stroke patients.
Fu et al., 2022	N=100	**INCLUSION CRITERIA:** Participants in the study had to be between the ages of 55 and 75, have had a stroke diagnosis	Acupuncture combined with rehabilitation therapy	Both groups got standard treatments, and the therapy was administered once daily for a total of four courses, each lasting seven days.	The outcome measures of the study was FMA scale, Barthel index	Acupuncture of traditional Chinese medicine combined with rehabilitation therapy has outstanding effects in stroke treatment

		verified by MRI or cranial CT, have experienced an attack within 7 days with stable vital signs, and provide their agreement. **EXCLUSION CRITERIA:** Patients who may faint during acupuncture, severe injuries, malignancies, having awareness problems, damage to vital organs other than the brain.				and can effectively improve the neurological function, prognosis, and quality of life of patients, which is worthy of clinical promotion.
Proiettei et al., 2023	N=10	**Inclusion criteria** ages of 18 and 85, speaking English well, having had a stroke more than six months prior, not having COVID-19 symptoms or a diagnosis within two weeks of the study starting or during the study, keeping their home safe from COVID-19, and consenting to researchers performing clinical evaluations there at initial, final, and follow-up visits while taking precautions **Exclusion criteria** Scored less than 23 on mini-metal state exam (MMSE), they had open wounds on impaired limb, they had any pain when ranging the impaired limb, they scored greater than 3 on MAS, they have received additional upper limb focused therapy while part of the study,	Self-rehabilitation	An 8-week home-based rehabilitation program under supervision (intervention group); the intervention group did not receive any therapy.	The outcome measures of the study was FMA-UE	Findings of the study show significant improvements in standard clinical metrics and range of motion at the end of the intervention. These promising results pave the way toward further investigation for the deployment of combined soft robotic/telerehabilitive systems at-home for autonomous usage for stroke rehabilitation.
Natta et al., 2021	N=95	**INCLUSION CRITERIA:** Adults over 20 who were released from inpatient, outpatient, or community physical rehabilitation treatments to reside in their own homes after suffering their first hemisphere stroke of ischemic or hemorrhagic origin **EXCLUSION CRITERIA:** Verified cerebellar stroke, brain stem,	Active	To enhance stroke therapy, a structured 6-month program utilizes text messaging, phone calls	The outcome measures of the study was SIS3.0	Post intervention intention-to-treat stroke patient through telerehabilitation or in clinic rehab found a no significant difference between the groups for physical and motor function.
Saywell et al., 2021	N=12	**INCLUSION CRITERIA:** Age more than eighteen, stroke (ischemic or intracerebral hemorrhage) that began three to twenty-four months earlier, arm FM scores	Home based telerehabilitation program	28 days of home-based therapy were provided to the participants, divided into two 14-day blocks of daily telerehabilitation interspersed with one to three-week breaks.	The outcome measure of the study was FM score.	Daily stroke education via the telerehabilitation system was associated with improvement in motor function recovery. This home-based system

		between 22 and 55, either grip strength greater than one kilogram, and visual acuity that is at least one week apart, Language or attention problems, as well as motor deficiencies, could not be unstable.				was effective in providing telerehabilitation, education, and secondary stroke prevention to participants. Use of a computer-based interface offers many opportunities to monitor and improve the health of patients after stroke.
Dodakian et al., 2017	N=59	**Inclusion criteria** At least 18 years old, with hemiparetic single stroke at least 6 months before inclusion of study, with no hospitalization during the 4 weeks before study living in or around the city, with Fugal-Meyer assessment-upper limb score 9 to 57 **EXCLUSION CRITERIA:** Visual neglect (Bells test score < 26/35), another illness or chronic stroke consequence, cognitive abnormalities (mini mental state examination score < 20)	Self-rehabilitation	An 8-week home-based rehabilitation program under supervision (intervention group); the intervention group did not receive any therapy.	The outcome measure of the study was FMA-UE	A self-rehabilitation program was effective in improving manual ability, grip force and quality of life in individuals with stroke.

Table-2 ROB of Included Studies

Study Included	Random Allocation	Allocation Concealment	Blinding Of Participant	Blinding Of Outcome Assessment	Incomplete Outcome Data	Selective Reporting
Shamweel et al., 2024	Yes	Yes	Yes	Yes	No	Yes
Saygili et al., 2024	Yes	Yes	Yes	No	No	Yes
Rossetto et al., 2024	Yes	Yes	No	Yes	No	Yes
Jin et al., 2023	Yes	Yes	No	Yes	No	Yes
Kang et al., 2023	Yes	No	No	Yes	No	Yes
Errante et al., 2022	Yes	Yes	Yes	Yes	Yes	Yes
Fu et al., 2022	Yes	No	No	No	Yes	Yes
Proiettei et al., 2023	Yes	Yes	Yes	No	No	Yes
Natta et al., 2021	Yes	Yes	No	Yes	Yes	Yes
Saywell et al., 2021	Yes	Yes	No	Yes	No	Yes
Dodakian et al., 2017	Yes	Yes	Yes	Yes	No	Yes

DISCUSSION

This systematic review investigates the effects of telerehabilitation versus supervised clinical rehabilitation in stroke patients for motor function recovery. Overall, across all trials, telerehabilitation was associated with improvements in motor function across the majority of primary and secondary measures. The moderate body of evidence comprised 11 RCTs. Telerehabilitation may be as effective as traditional therapy for motor function, ADLs, independence, and satisfaction/quality of life, according to the review's summary conclusions. This favorable result could also apply to patient satisfaction, a measure reflecting the patient's perspective.

The findings of this review align with previous studies, such as those by Chen et al. (2017)[28], which demonstrated that telerehabilitation is likely as effective as traditional outpatient rehabilitation, enhancing functional recovery in stroke patients and reducing caregiver burden. A further systematic review by Sharififar et al.[29] supports the notion that telerehabilitation can enhance functional outcomes and encourage therapy adherence after stroke. Other studies by Hestetun-Mandrup et al.[30] and Knepley et al.[31] indicate that telerehabilitation may replace clinic-based rehabilitation for stroke survivors since it produces similar functional outcomes.

This evaluation aimed to inform clinical practice and support decision-making for patients and healthcare professionals, given the growing importance of technology in healthcare and its potential to overcome access barriers. In clinical contexts, telerehabilitation may provide additional advantages including improved patient access to therapy, reduced hospital travel expenses, and increased staff productivity, even if it may not be superior to traditional treatment methods. An interesting finding in this research is the use of current research and various technological and digital rehabilitation interventions delivered through both telerehabilitation and clinical settings. This research primarily focuses on motor functions and measures patient independence levels after stroke. The study results may not apply to all stroke patients, particularly those with severe impairments. Patient adherence to rehabilitation protocols can vary, potentially impacting the findings and generalizability of the study.

CONCLUSION

The review demonstrates that patients who received rehabilitation services through telerehabilitation showed significant improvement in motor function and reported the highest satisfaction with outcomes. These findings inform healthcare practitioners' decision-making and highlight the importance of technology in healthcare and its capacity to overcome barriers.
Future research should prioritize long-term follow-up assessments to cover the complete spectrum of stroke rehabilitation and customize interventions to meet the specific requirements and objectives of individual patients.

AUTHORS' CONTRIBUTION:
The following authors have made substantial contributions to the manuscript as under:
Conception or Design: Atif Ahmed Khan
Acquisition, Analysis, or Interpretation of Data: Bisma Hakeem, Hafsa Rafiq, Ali Abid, Muhammad Hanzalah Atif
Manuscript Writing and Final Approval: All authors

All authors acknowledge their accountability for all facets of the research, ensuring that any concerns regarding the accuracy or integrity of the work are duly investigated and resolved.

ACKNOWLEDGEMENTS: None

INFORMED CONSENT: Written Informed Consent was taken from each patient.

CONFLICT OF INTEREST: None declared.

FUNDING STATEMENTS: None

ETHICS STATEMENTS: The research was approved by an independent Institutional Review Board (IRB) at Foundation of Medical Research and Laboratories (FMRL) under the IRB Protocol Number: FMRL-IRB/2025/010.

REFERENCES

1. Béjot Y, Bailly Hurier J, et al. Epidemiology of stroke in Europe and trends for the 21st century. Presse Med. 2016;45:e391-e3e8.
2. Dunbar M, Kirton A. Perinatal stroke. Seminars in Pediatric Neurology. 2019;32:100767.
3. Ogunniyi A. Global evidence generation. Oxford Textbook of Neurologic and Neuropsychiatric Epidemiology. 2020 Nov 2;27(23,032,796):453.
4. Eraifej J, Clark W, France B, et al. Effectiveness of upper limb functional electrical stimulation after stroke for the improvement of activities of daily living and motor function: a systematic review and meta-analysis. Syst Rev. 2017;6(1):40.
5. Henderson SJ, Weitz JI, Kim PY. Fibrinolysis: strategies to enhance the treatment of acute ischemic stroke. Journal of Thrombosis and Haemostasis. 2018;16(10):1932-1940.
6. Rogers G, Davies D, Pink J, et al. Parkinson's disease: Summary of updated NICE guidance. BMJ. 2017;358:j1951.
7. Johansson T, Wild C. Telerehabilitation in stroke care--a systematic review. Journal of Telemedicine and Telecare. 2011;17(1):1-6.
8. Nikolaev VA, Nikolaev AA. Recent trends in telerehabilitation of stroke patients: A narrative review. NeuroRehabilitation. 2022 Jan 1;51(1):1-22.
9. Laver KE, Adey-Wakeling Z, Crotty M, et al. Telerehabilitation services for stroke. Cochrane Database Syst Rev. 2020;1(1):CD010255.
10. Hernandez A, Bubyr L, Archambault PS, Higgins J, Levin MF, Kairy D. Virtual reality--based rehabilitation as a feasible and engaging tool for the management of chronic poststroke upper-extremity function recovery: Randomized controlled trial. JMIR Serious Games. 2022 Sep 27;10(3):e37506.
11. Perle JG, Zheng W. A primer for understanding and utilizing telesupervision with healthcare trainees. Journal of Technology in Behavioral Science. 2024 Mar;9(1):46-52.
12. Appleby E, Gill ST, Hayes LK, Walker TL, Walsh M, Kumar S. Effectiveness of telerehabilitation in the management of adults with stroke: A systematic review. PLoS One. 2019 Nov 12;14(11):e0225150.
13. Conroy SS, Harcum S, Keldsen L, Bever Jr CT. Novel use of existing technology: a preliminary study of patient portal use for telerehabilitation. Journal of Telemedicine and Telecare. 2022 Jun;28(5):380-8.
14. Gauthier LV, Nichols-Larsen DS, Uswatte G, Strahl N, Simeo M, Proffitt R, Kelly K, Crawfis R, Taub E, Morris D, Lowes LP. Video game rehabilitation for outpatient stroke (VIGoROUS): a multi-site randomized controlled trial of in-home, self-managed, upper-extremity therapy. EClinicalMedicine. 2022 Jan 1;43:101239.
15. Krpic A, Savanovic A, Cikajlo I. Telerehabilitation: remote multimedia-supported assistance and mobile monitoring of balance training outcomes can facilitate the clinical staff's effort. International Journal of Rehabilitation Research. 2013 Jun 1;36(2):162-71.

16. Higgins JPTTJ, Chandler J, Cumpston M, et al. Cochrane handbook for systematic reviews of interventions version 6. 2021.
17. Shamweel H, Gupta N. Constraint-induced movement therapy through telerehabilitation for upper extremity function in stroke. Journal of Neurorestoratology. 2024 Jun 1;12(2):100108.
18. Saygili F, Guclu-Gunduz A, Eldemir S, Eldemir K, Ozkul C, Gursoy GT. Effects of modified constraint induced movement therapy based telerehabilitation on upper extremity motor functions in stroke patients. Brain and Behavior. 2024 Jun;14(6):e3569.
19. Zhang Y, Jin Q, Ji C, Yuan P, Chen L. Innovative Telerehabilitation Enhanced Care Programme (ITECP) in young and middle-aged patients with haemorrhagic stroke to improve exercise adherence: protocol of a multicentre randomised controlled trial. BMJ Open. 2023 Dec 1;13(12):e072268.
20. Rossetto F, Mestanza Mattos FG, Gervasoni E, Germanotta M, Pavan A, Cattaneo D, Aprile I, Baglio F. Efficacy of telerehabilitation with digital and robotic tools for the continuity of care of people with chronic neurological disorders: The TELENEURO@ REHAB protocol for a randomized controlled trial. Digital Health. 2024 Mar;10:20552076241228928.
21. Proietti T, Nuckols K, Grupper J, de Lucena DS, Inirio B, Porazinski K, Wagner D, Cole T, Glover C, Mendelowitz S, Herman M. Combining soft robotics and telerehabilitation for improving motor function after stroke. Wearable Technologies. 2024 Jan;5:e1.
22. Saywell NL, Vandal AC, Mudge S, Hale L, Brown P, Feigin V, Hanger C, Taylor D. Telerehabilitation after stroke using readily available technology: a randomized controlled trial. Neurorehabilitation and Neural Repair. 2021 Jan;35(1):88-97.
23. Dodakian L, McKenzie AL, Le V, See J, Pearson-Fuhrhop K, Burke Quinlan E, Zhou RJ, Augsberger R, Tran XA, Friedman N, Reinkensmeyer DJ. A home-based telerehabilitation program for patients with stroke. Neurorehabilitation and Neural Repair. 2017 Oct;31(10-11):923-33.
24. Home-Based Virtual Reality Exergame Program after Stroke Rehabilitation for Patients with Stroke: A Study Protocol for a Multicenter, Randomized Controlled Trial. Life. 2023;13(12):2256.
25. Appleby E, Gill ST, Hayes LK, Walker TL, Walsh M, Kumar S. Effectiveness of telerehabilitation in the management of adults with stroke: A systematic review. PLoS One. 2019 Nov 12;14(11):e0225150.
26. Chen J, Jin W, Zhang XX, Xu W, Liu XN, Ren CC. Telerehabilitation approaches for stroke patients: systematic review and meta-analysis of randomized controlled trials. Journal of Stroke and Cerebrovascular Diseases. 2015 Dec 1;24(12):2660-8.
27. Zhang Y, Jin Q, Ji C, Yuan P, Chen L. Innovative Telerehabilitation Enhanced Care Programme (ITECP) in young and middle-aged patients with haemorrhagic stroke to improve exercise adherence: protocol of a multicentre randomised controlled trial. BMJ Open. 2023 Dec 1;13(12):e072268.
28. Chen J, Jin W, Dong WS, Jin Y, Qiao FL, Zhou YF, Ren CC. Effects of home-based telesupervising rehabilitation on physical function for stroke survivors with hemiplegia: a randomized controlled trial. American Journal of Physical Medicine & Rehabilitation. 2017 Mar 1;96(3):152-60.

29. Sharififar S, Ghasemi H, Geis C, Azari H, Adkins L, Speight B, Vincent HK. Telerehabilitation service impact on physical function and adherence compared to face-to-face rehabilitation in patients with stroke: A systematic review and meta-analysis. PM&R. 2023 Dec;15(12):1654-72.
30. Hestetun-Mandrup AM, Toh ZA, Oh HX, He HG, Martinsen AC, Pikkarainen M. Effectiveness of digital home rehabilitation and supervision for stroke survivors: A systematic review and meta-analysis. Digital Health. 2024 Jun;10:20552076241256861.
31. Asano M, Tai BC, Yeo FY, Yen SC, Tay A, Ng YS, De Silva DA, Caves K, Chew E, Hoenig H, Koh GC. Home-based tele-rehabilitation presents comparable positive impact on self-reported functional outcomes as usual care: the Singapore tele-technology aided rehabilitation in stroke (STARS) randomised controlled trial. Journal of Telemedicine and Telecare. 2021 May;27(4):231-8.