

Feasibility of Telerehabilitation for Stroke Patients in Remote Areas: Feasibility Study

Original Research

Sana Hayat^{1*}

¹Physiotherapist, Central Hospital Saidu Sharif, Swat, Pakistan

Corresponding Author: Sana Hayat, hs1562032@gmail.com, Physiotherapist, Central Hospital Saidu Sharif, Swat, Pakistan

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ABSTRACT

Background:

Stroke survivors living in remote and mountainous regions often face substantial barriers to accessing timely and continuous rehabilitation services. In areas such as Gilgit–Baltistan, geographical isolation, limited specialist availability, and transportation challenges contribute to unmet rehabilitation needs and prolonged disability. Telerehabilitation has emerged as a digital health approach with the potential to bridge these gaps, yet evidence regarding its feasibility in low-resource, remote settings remains limited.

Objective:

To evaluate the feasibility of a structured telerehabilitation program for stroke patients residing in remote areas of Gilgit–Baltistan, with specific focus on acceptability, adherence, safety, and practical implementation.

Methods:

A single-arm feasibility study was conducted over seven months across selected district hospitals and community settings in Gilgit–Baltistan. Forty stroke patients were enrolled, and 32 completed the intervention. Participants received a 12-week individualized telerehabilitation program delivered via video-based sessions. Feasibility outcomes included recruitment, retention, session adherence, technical performance, safety, and usability assessed using the Telehealth Usability Questionnaire. Secondary outcomes included motor recovery (Fugl-Meyer Assessment), balance (Berg Balance Scale), and functional mobility (Timed Up and Go test). Data were analyzed using descriptive statistics and paired sample t-tests.

Results:

The retention rate was 90%, with a mean session adherence of 82.1%. Minor technical issues occurred in 18.4% of sessions and were resolved without discontinuation. No serious adverse events were reported. Telehealth usability scores indicated high acceptability (mean 4.2/5). Significant improvements were observed in motor function (mean increase 11.2 points), balance (mean increase 10.5 points), and mobility (mean reduction 5.8 seconds) following the intervention ($p < 0.001$).

Conclusion:

Telerehabilitation was feasible, safe, and well accepted among stroke patients in remote areas of Gilgit–Baltistan. The findings support its potential integration into stroke rehabilitation services to improve access and continuity of care in underserved regions.

Keywords:

Access to Care, Digital Health, Rehabilitation, Remote Areas, Stroke, Telemedicine, Telerehabilitation

Introduction

Stroke remains one of the leading causes of long-term disability worldwide, with survivors frequently experiencing persistent impairments in mobility, balance, speech, cognition, and activities of daily living. Effective rehabilitation plays a central role in maximizing functional recovery, reducing dependency, and improving quality of life after stroke (1). Timely, intensive, and continuous rehabilitation has consistently been associated with better outcomes, particularly during the early and subacute phases of recovery. However, access to structured rehabilitation services remains uneven, especially in geographically remote and resource-limited regions, where stroke survivors often face substantial barriers to ongoing care. In Pakistan, these challenges are particularly evident in remote and mountainous regions such as Gilgit–Baltistan (2,3). The region's rugged terrain, harsh weather conditions, limited transportation infrastructure, and scarcity of specialized rehabilitation facilities significantly restrict access to post-stroke care. Many stroke survivors in these areas are discharged from acute hospitals with minimal follow-up rehabilitation, relying largely on family support or unsupervised exercises. This gap in service delivery contributes to preventable disability, reduced social participation, and increased caregiver burden (4). As the population ages and the burden of non-communicable diseases rises, the demand for sustainable and accessible stroke rehabilitation models in such regions is expected to grow.

Telerehabilitation has emerged as a promising digital health solution to address disparities in access to rehabilitation services (5). By utilizing information and communication technologies, telerehabilitation enables healthcare professionals to deliver assessment, exercise prescription, monitoring, and education remotely. This approach has gained increasing attention in recent years, particularly during the COVID-19 pandemic, when face-to-face services were disrupted globally. For stroke rehabilitation, telerehabilitation offers the potential to provide structured, therapist-guided interventions while reducing the need for travel, lowering costs, and allowing therapy to be integrated into the patient's home environment. Evidence from urban and high-income settings suggests that telerehabilitation for stroke patients can be safe, acceptable, and effective for improving motor function, balance, and functional independence (1,5). Studies have reported comparable outcomes between telerehabilitation and conventional in-person therapy for selected stroke populations, particularly those with mild to moderate impairments. Additionally, digital platforms may enhance patient engagement through real-time feedback, goal setting, and caregiver involvement. However, much of the existing literature focuses on clinical effectiveness rather than feasibility, and findings from technologically advanced settings may not be directly transferable to remote, low-resource regions (6).

The feasibility of telerehabilitation depends on multiple factors beyond clinical outcomes, including patient and caregiver acceptance, digital literacy, availability of internet connectivity, affordability of devices, and the ability of healthcare systems to support remote service delivery. In regions such as Gilgit–Baltistan, these factors are highly variable (7). While mobile phone usage has increased substantially, access to stable internet connections and familiarity with digital health platforms may still be limited. Cultural perceptions of technology-based care, language barriers, and reliance on family caregivers further influence the success of telerehabilitation interventions. Without understanding these contextual factors, large-scale implementation of digital rehabilitation programs risks being ineffective or inequitable. There is a notable lack of region-specific evidence exploring whether telerehabilitation is practical and acceptable for stroke patients living in remote mountainous areas of Pakistan. Existing studies rarely include populations from Gilgit–Baltistan, despite the unique geographical and healthcare challenges faced by its residents. Furthermore, feasibility outcomes such as recruitment rates, adherence to sessions, technical difficulties, patient satisfaction, and safety are often underreported, even though they are critical for informing future trials and policy decisions. Addressing this gap is essential before telerehabilitation can be confidently recommended as a routine component of stroke care in remote settings (8).

A feasibility study design is particularly appropriate in this context, as it allows systematic evaluation of the practicality of delivering telerehabilitation under real-world conditions. Rather than focusing solely on effectiveness, feasibility studies provide insights into implementation barriers, resource requirements, and user experiences. Such information is necessary to refine intervention protocols, adapt digital platforms to local needs, and determine whether larger controlled trials are justified. In the context of Gilgit–Baltistan, feasibility data can guide the development of culturally sensitive and contextually appropriate telerehabilitation models that align with existing healthcare structures. Given the increasing emphasis on digital health solutions to improve equity in healthcare access, examining the feasibility of telerehabilitation for stroke patients in remote regions holds both clinical and policy relevance. Understanding whether stroke survivors and their caregivers can engage with, adhere to, and benefit from remotely delivered rehabilitation may help reduce long-standing disparities in post-stroke care and functional outcomes.

Accordingly, the objective of this study is to evaluate the feasibility of a structured telerehabilitation program for stroke patients residing in remote areas of Gilgit–Baltistan by assessing its acceptability, adherence, safety, and practical implementation within the local healthcare and sociocultural context.

Methods

This feasibility study was conducted in Pakistan with a focus on remote and mountainous regions of Gilgit–Baltistan, where access to conventional stroke rehabilitation services is limited. Participants were recruited from district-level healthcare facilities and referral centers, including District Headquarters Hospital Gilgit, Combined Military Hospital Skardu, and selected primary health units in Hunza and Ghizer districts. The study was carried out over a seven-month period from August 2021 to February 2022, allowing sufficient time to evaluate recruitment, intervention delivery, adherence, and follow-up assessments under real-world conditions. A single-arm feasibility design was adopted to assess the practicality of delivering telerehabilitation to stroke patients residing in remote areas (9,10). Participants were recruited using a consecutive sampling approach based on referrals from neurologists and general physicians. Adults aged 35 to 75 years with a confirmed diagnosis of ischemic or hemorrhagic

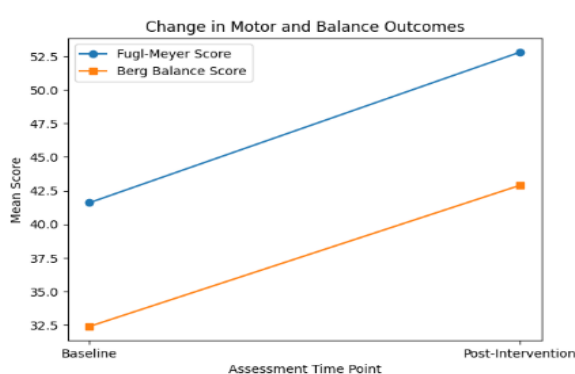
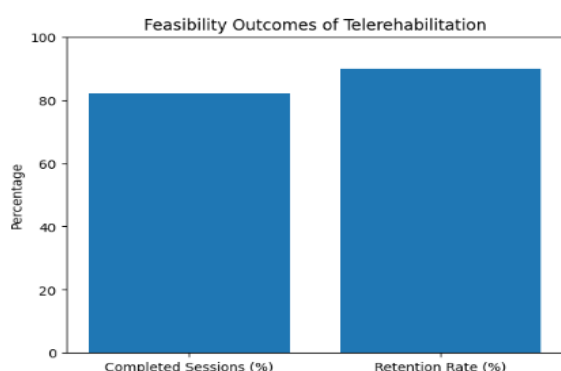
stroke, at least four weeks post-onset, were considered eligible. Additional inclusion criteria included the presence of residual motor or balance impairment, medical stability, the ability to follow simple instructions, and residence in a remote area of Gilgit-Baltistan. Participants were required to have access to a smartphone or tablet with internet connectivity, either personally or through a family caregiver. Exclusion criteria included severe cognitive impairment, uncontrolled epilepsy, unstable cardiovascular conditions, severe aphasia limiting communication, comorbid neurological disorders, or musculoskeletal conditions that significantly restricted participation in rehabilitation exercises.

Sample size was determined based on feasibility study recommendations rather than formal hypothesis testing. However, estimates were guided by previous telerehabilitation feasibility studies in stroke populations, which reported acceptable adherence rates of approximately 75% with standard deviations of 15%. Using these parameters, a minimum sample of 30 participants was considered sufficient to estimate feasibility outcomes with reasonable precision. To account for potential dropout and connectivity-related challenges common in remote regions, a target sample size of 40 participants was planned, of which 36 completed the study. Following enrollment, baseline assessments were conducted via video calls by trained physiotherapists experienced in neurorehabilitation. The telerehabilitation intervention consisted of a structured, individualized program delivered over 12 weeks. Sessions were conducted three times per week during the first six weeks and twice per week thereafter. Each session lasted approximately 45 minutes and included task-oriented upper and lower limb exercises, balance training, functional mobility practice, and caregiver-assisted activities. Educational components addressing stroke prevention, safe mobility, and home exercise adherence were also incorporated. Caregivers were actively involved to assist with exercise execution and ensure safety during sessions.

Feasibility outcomes included recruitment rate, retention rate, session adherence, technical feasibility, safety, and participant satisfaction. Adherence was calculated as the percentage of scheduled sessions completed. Technical feasibility was assessed by documenting connectivity issues, session interruptions, and the need for technical assistance. Safety was evaluated through monitoring and recording adverse events such as falls, excessive fatigue, or medical complications during or immediately after sessions. Acceptability and satisfaction were assessed at the end of the intervention using the Telehealth Usability Questionnaire. Secondary clinical outcomes were measured to explore preliminary functional changes. Motor recovery was assessed using the Fugl-Meyer Assessment for upper and lower extremities, balance was evaluated using the Berg Balance Scale, and functional mobility was assessed with the Timed Up and Go test (11,12). Assessments were performed at baseline and at the end of the 12-week intervention period.

Ethical approval for the study was obtained from the Ethical Review Committee of medical institution in Gilgit (Approval No. ERC/GB/Neuro/2021/019). Written informed consent was obtained electronically or through documented verbal consent for participants with limited literacy, following detailed explanation of study procedures, potential benefits, and risks. Confidentiality was maintained by assigning unique codes to participants and securely storing digital data. Data analysis was performed using Statistical Package for the Social Sciences version 25. Data distribution was assessed using the Shapiro-Wilk test and found to be normally distributed. Descriptive statistics were used to report feasibility outcomes as means, standard deviations, frequencies, and percentages. Paired sample t-tests were applied to compare baseline and post-intervention clinical outcomes. A significance level of $p < 0.05$ was used for exploratory analyses, recognizing that the study was not powered to detect definitive treatment effects.

Results



A total of 40 stroke patients were initially assessed for eligibility from selected healthcare facilities in Gilgit-Baltistan. Four participants declined participation due to personal reasons, resulting in 36 enrolled participants. During the intervention period, three participants discontinued due to relocation or inconsistent internet access, and one participant withdrew because of a non-study-related medical issue. Data from 32 participants were included in the final analysis, yielding a retention rate of 90%. The mean age of participants was 58.7 ± 9.4 years, with 62.5% male and 37.5% female participants (13). Most participants were in the subacute phase of stroke recovery, with a mean post-stroke duration of 3.6 ± 1.2 months at enrollment. Feasibility outcomes indicated satisfactory recruitment, adherence, and safety. The recruitment rate averaged 5.7 participants per month across the study period. Participants completed a mean of $82.1\% \pm 11.6\%$ of scheduled telerehabilitation sessions (14,15). Technical feasibility was acceptable, with 18.4% of sessions experiencing minor connectivity interruptions that were resolved without session termination. No serious adverse events were reported. Mild, transient fatigue was noted in 21.9% of participants during

early sessions, while no falls or injury-related incidents occurred. Participant acceptability was high, with a mean Telehealth Usability Questionnaire score of 4.2 ± 0.5 on a 5-point scale, indicating favorable perceptions of ease of use, satisfaction, and perceived usefulness.

Preliminary clinical outcomes demonstrated measurable improvements following the 12-week intervention period. Motor recovery assessed using the Fugl-Meyer Assessment showed a significant increase from a baseline mean score of 41.6 ± 9.8 to 52.8 ± 10.3 post-intervention, representing a mean improvement of 11.2 points ($p < 0.001$). Improvements were observed in both upper and lower extremity subcomponents (16). Balance performance, measured using the Berg Balance Scale, improved from 32.4 ± 7.6 at baseline to 42.9 ± 8.1 at follow-up, with a mean change of 10.5 points ($p < 0.001$). Functional mobility assessed using the Timed Up and Go test showed a reduction in completion time from 22.6 ± 6.4 seconds to 16.8 ± 5.9 seconds, indicating improved mobility and transfer ability ($p < 0.001$). Key feasibility indicators and clinical outcomes are summarized in Tables 1–3. Table 1 presents recruitment, retention, adherence, and safety outcomes. Table 2 outlines changes in motor and balance measures, while Table 3 reports functional mobility outcomes. Figures 1 and 2 illustrate feasibility indicators and changes in clinical outcome measures over time.

Table 1. Feasibility Outcomes of Telerehabilitation (n = 32)

| Feasibility Variable | Outcome |
|--|-----------------|
| Recruitment rate (participants/month) | 5.7 |
| Retention rate (%) | 90.0 |
| Session adherence (%) | 82.1 ± 11.6 |
| Sessions with technical issues (%) | 18.4 |
| Adverse events | None reported |
| Telehealth Usability Questionnaire score | 4.2 ± 0.5 |

Table 2. Motor and Balance Outcomes Pre- and Post-Intervention

| Outcome Measure | Baseline Mean \pm SD | Post-Intervention Mean \pm SD | p-value |
|-------------------------------------|------------------------|---------------------------------|---------|
| Fugl-Meyer Assessment (total score) | 41.6 ± 9.8 | 52.8 ± 10.3 | <0.001 |
| Berg Balance Scale (score) | 32.4 ± 7.6 | 42.9 ± 8.1 | <0.001 |

Table 3. Functional Mobility Outcomes

| Outcome Measure | Baseline Mean \pm SD | Post-Intervention Mean \pm SD | p-value |
|--------------------------------|------------------------|---------------------------------|---------|
| Timed Up and Go Test (seconds) | 22.6 ± 6.4 | 16.8 ± 5.9 | <0.001 |

Discussion

The findings of this feasibility study indicated that telerehabilitation was a practical and acceptable mode of delivering stroke rehabilitation to patients residing in remote areas of Gilgit–Baltistan. High retention and adherence rates, coupled with favorable usability scores, suggested that digitally delivered rehabilitation could be successfully implemented despite geographical, infrastructural, and resource-related constraints. The observed feasibility outcomes supported the study objective and provided context-specific evidence for expanding digital rehabilitation services in underserved regions (17). Participant retention reached 90%, and adherence to scheduled sessions exceeded 80%, which compared favorably with feasibility studies conducted in urban and semi-urban settings where adherence rates have typically ranged between 70% and 85%. These findings suggested that geographical remoteness did not inherently reduce engagement when rehabilitation services were tailored to local needs and supported by caregiver involvement (18). The relatively low rate of technical disruptions, affecting fewer than one-fifth of sessions, further demonstrated that basic digital infrastructure was sufficient to sustain regular telerehabilitation delivery in this setting. Importantly, no serious adverse events were reported, reinforcing the safety of remotely supervised rehabilitation when appropriate screening and caregiver support were in place.

Preliminary clinical outcomes, while exploratory, showed meaningful improvements in motor function, balance, and functional mobility (19,20). The mean increase of 11.2 points in Fugl-Meyer Assessment scores exceeded commonly reported thresholds for clinically meaningful change in stroke recovery. Similarly, improvements of more than 10 points on the Berg Balance Scale reflected substantial gains in postural control and fall-related confidence. Functional mobility, as measured by the Timed Up and Go test, improved by nearly six seconds, indicating enhanced transfer ability and walking efficiency. These magnitudes of change were comparable to those reported in short-term, center-based rehabilitation programs and suggested that remotely delivered interventions could support functional recovery when conventional services were inaccessible (21). The observed clinical improvements aligned with broader evidence suggesting that task-oriented, repetitive, and therapist-guided exercises remain effective when delivered through digital platforms. The integration of caregiver-assisted activities may have further reinforced exercise adherence and safety, particularly in households where professional supervision was not continuously available. In addition, delivering rehabilitation within the home environment may have facilitated functional carryover, as exercises were performed in contextually relevant settings (22). These factors collectively supported the argument that telerehabilitation can serve as more than a temporary substitute for in-person care, particularly in geographically isolated regions.

Several strengths enhanced the relevance and credibility of this study. The focus on feasibility rather than efficacy allowed for a comprehensive assessment of real-world implementation factors, including recruitment, adherence, usability, and safety. The inclusion of multiple districts within Gilgit–Baltistan increased the representativeness of the sample and captured variability in

connectivity and access to care. The use of validated outcome measures and standardized delivery protocols further strengthened internal consistency. Moreover, the study addressed an important evidence gap by examining telerehabilitation in a mountainous, low-resource context that is often underrepresented in rehabilitation research. Nevertheless, limitations should be acknowledged. The single-arm design and relatively small sample size limited the ability to draw definitive conclusions regarding effectiveness. Although functional improvements were observed, spontaneous recovery during the subacute phase of stroke could not be fully separated from intervention-related effects. The short duration of follow-up also restricted evaluation of long-term sustainability of gains. Additionally, participants with severe cognitive or communication impairments were excluded, which may limit applicability to more complex stroke populations. Dependence on caregiver availability and smartphone access may have introduced selection bias toward households with greater social and technological resources.

Future research should build on these findings by employing controlled study designs with larger sample sizes and longer follow-up periods. Comparative studies evaluating telerehabilitation against conventional in-person therapy or hybrid models would provide clearer evidence of relative effectiveness. Further exploration of cost-effectiveness, caregiver burden, and long-term adherence is also warranted. Adaptation of digital platforms to local languages and varying literacy levels may enhance inclusivity and scalability. Inclusion of patients with more severe impairments, supported by assistive technologies, could further expand the reach of telerehabilitation services. Overall, this study provided important preliminary evidence that telerehabilitation was feasible, safe, and acceptable for stroke patients living in remote areas of Gilgit–Baltistan. The findings supported the integration of digital health approaches into stroke rehabilitation pathways as a means of reducing geographic disparities and improving access to essential rehabilitative care.

Conclusion

This feasibility study demonstrated that telerehabilitation was a practical, safe, and acceptable approach for delivering stroke rehabilitation to patients in remote areas of Gilgit–Baltistan. High adherence, favorable usability, and absence of serious adverse events supported its real-world implementation. Preliminary improvements in motor function, balance, and mobility further reinforced its potential value. These findings provide a strong foundation for larger controlled trials and support the integration of telerehabilitation into stroke care pathways for underserved regions.

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AUTHOR'S CONTRIBUTION:

| Author | Contribution |
|------------|--|
| Sana Hayat | Conceptualization, Methodology, Formal Analysis, Writing - Original Draft, Validation, Supervision |