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Original Article

Impact of Home-Based Rehabilitation Programs on Stroke Survivors in Rural Areas of Sindh

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ABSTRACT

Background: Stroke is a major cause of long-term disability worldwide, with rural populations in low- and middle-income countries disproportionately affected due to limited access to rehabilitation services. In Pakistan's rural Sindh, geographic, financial, and infrastructural barriers frequently prevent timely, sustained therapy, resulting in prolonged disability and dependency. Home-based rehabilitation (HBR) has emerged as a practical alternative, offering structured exercises and caregiver-supported recovery within the patient's environment. Evidence for its effectiveness in rural Pakistan remains scarce. Objective: To evaluate the impact of an eight-week structured home-based rehabilitation program on independence in activities of daily living (ADLs), balance, mobility, and quality of life among stroke survivors in rural Larkana, Sindh. Methods: A quasi-experimental pre–post study was conducted between March and September 2024 involving 40 stroke survivors aged 40–75 years, recruited via purposive sampling. Inclusion criteria comprised medically stable patients 6 months to 2 years post-stroke, with Modified Rankin Scale scores of 2–4. Participants received a tailored HBR program six days per week for 45–60 minutes per session, integrating range-of-motion, strengthening, balance, mobility, and ADL training, alongside caregiver education. Outcomes—Barthel Index (BI), Berg Balance Scale (BBS), Timed Up and Go (TUG), and Stroke-Specific Quality of Life Scale (SS-QOL)—were measured at baseline and week 8. Paired t-tests, 95% confidence intervals, and effect sizes quantified changes. Results: Significant post-intervention gains were observed in BI (+22.7, 95% CI 18.4–27.0, $p<0.001$, $d=1.64$), BBS (+12.7, 95% CI 10.1–15.3, $p<0.001$, $d=1.77$), and SS-QOL (+25.7, 95% CI 20.8–30.6, $p<0.001$, $d=1.45$), with a reduction in TUG time (−7.5 sec, 95% CI −9.3 to −5.7, $p<0.001$, $d=1.27$). Caregiver support was reported in 90% of households, adherence averaged 87.5%, and no adverse events occurred. Conclusion: Structured home-based rehabilitation is an effective, safe, and acceptable intervention for improving functional independence, balance, mobility, and quality of life in rural stroke survivors. Integration into rural health services, supported by caregiver training and periodic professional oversight, may help address the post-stroke rehabilitation gap in underserved areas.

Keywords: stroke rehabilitation, home-based therapy, rural health, functional recovery, Pakistan, caregiver support.

INTRODUCTION

Stroke is a leading cause of long-term disability and mortality worldwide, with approximately 15 million new cases annually, of which nearly five million individuals are left permanently disabled (1). The burden is disproportionately high in low- and middle-income countries due to limited access to acute care, rehabilitation facilities, and preventive strategies. In Pakistan, the incidence and prevalence of stroke continue to rise, driven by increasing cardiovascular risk factors, inadequate preventive health infrastructure, and suboptimal post-acute care systems (2). These challenges are particularly acute in rural regions such as Larkana in interior Sindh, where specialist rehabilitation services are scarce, transportation is difficult, and financial constraints hinder continuity of care (3). Without timely and adequate rehabilitation, many survivors face prolonged disability, dependency in activities of daily living (ADLs), and diminished quality of life (4).

Rehabilitation after stroke is most effective when initiated early, delivered intensively, and sustained over time through structured programs involving multidisciplinary teams. However, conventional hospital- or clinic-based models, while effective in high-resource settings, are not feasible for many rural populations due to geographic inaccessibility, costs, and workforce shortages (5). These barriers contribute to low adherence, delayed recovery, and increased caregiver burden (6). Home-based rehabilitation (HBR) offers a practical alternative, enabling structured physiotherapy, functional training, and caregiver-assisted activities within the patient's own environment. This model

reduces the need for travel, fosters functional recovery in familiar surroundings, and can be adapted to local cultural and socioeconomic contexts (7). International evidence suggests that HBR can yield comparable or superior outcomes to institutional rehabilitation in terms of motor recovery, balance, mobility, and psychosocial well-being, especially when caregiver engagement is high (8,9). Furthermore, its cost-effectiveness and potential to be scaled through community health worker integration make it an appealing solution for resource-limited regions (10).

In Pakistan, data on the effectiveness of HBR for stroke survivors in rural settings remain scarce, with most published studies focusing on urban populations or institutional rehabilitation. This knowledge gap limits the development of context-specific policies and interventions that address the realities of rural communities. Cultural beliefs regarding disability, limited awareness of rehabilitation benefits, and lack of structured caregiver training further impede recovery in these settings (11,12). Addressing these barriers through culturally sensitive, low-cost, and professionally supervised home-based programs could improve functional independence, enhance mobility, and improve quality of life for stroke survivors (13).

Given this background, the present study evaluates the impact of an eight-week structured home-based rehabilitation program on functional outcomes—including independence in ADLs, balance, mobility, and quality of life—in stroke survivors residing in rural areas of Larkana, Sindh. The program incorporates individualized exercise prescriptions, caregiver training, and regular follow-up to optimize adherence and safety. The primary objective is to determine whether such an intervention leads to statistically and clinically significant improvements in validated outcome measures compared to baseline. The study hypothesis posits that participation in this structured HBR program will result in measurable gains in functional independence, mobility, and quality of life among rural stroke survivors (14).

MATERIAL AND METHODS

This quasi-experimental pre–post study was conducted to assess the effectiveness of a structured home-based rehabilitation program in improving functional outcomes among stroke survivors in rural areas of Larkana District, Sindh, Pakistan. The study was implemented between March and September 2024, encompassing participant recruitment, intervention delivery, and follow-up assessments. The setting included participants' residences in rural communities, with initial contact established through local public hospitals, primary healthcare centers, and community health workers familiar with the target population. This design was selected to evaluate real-world feasibility and clinical impact in a naturalistic home environment, reflecting conditions where institutional rehabilitation services are largely inaccessible (15).

Eligible participants were adults aged 40 to 75 years with a confirmed diagnosis of ischemic or hemorrhagic stroke within the preceding 6 months to 2 years, as verified by a neurologist through clinical examination and neuroimaging. All participants were medically stable, cleared for physical activity by their treating physician, and had a Modified Rankin Scale score between 2 and 4, indicating partial dependency but preserved capacity for rehabilitation. Additional inclusion criteria included residence in a rural area of Larkana, the ability to follow instructions independently or with caregiver support, and provision of written informed consent by the patient or primary caregiver.

Exclusion criteria encompassed severe cognitive impairment (Mini-Mental State Examination score <20), unstable medical or cardiovascular conditions, significant musculoskeletal or orthopedic limitations that would interfere with exercise performance, prior participation in structured rehabilitation within the last 3 months, a Rankin score of 5 indicating complete dependency, and refusal to participate (16). Purposive sampling was employed to enroll 40 eligible individuals, with recruitment facilitated by local health professionals to ensure representation of the rural population.

The intervention consisted of an eight-week structured home-based rehabilitation program designed by a licensed physiotherapist and tailored to each participant's functional status and recovery goals. Sessions were scheduled six days per week, lasting 45 to 60 minutes each. The rehabilitation regimen included passive and active-assisted range of motion exercises, progressive strengthening of upper and lower limbs using body weight and resistance bands, static and dynamic balance training such as single-leg stance and tandem walking, functional mobility drills including bed-to-chair transfers and gait training with assistive devices, and task-oriented activities targeting independence in ADLs such as dressing, grooming, and feeding. Caregiver education formed an integral component, providing instruction on safe exercise assistance, monitoring of fatigue or adverse symptoms, and environmental modifications to reduce fall risk (17). An initial home visit was conducted to demonstrate exercises and distribute printed instruction sheets with illustrations. Follow-up was maintained through weekly phone or video calls, with in-person visits at weeks 4 and 8 to assess progress, adjust exercises, and reinforce caregiver guidance.

Outcome assessment focused on four validated measures: the Barthel Index (BI) for ADL independence, the Berg Balance Scale (BBS) for postural stability, the Timed Up and Go (TUG) test for functional mobility, and the Stroke-Specific Quality of Life Scale (SS-QOL) for multidimensional quality of life evaluation. All measures were administered at baseline (pre-intervention) and at the end of the eight-week program (post-intervention) by trained assessors blinded to intervention specifically. Adherence was operationally defined as the proportion of prescribed sessions completed, calculated from participant and caregiver logs. Potential biases, including performance and measurement bias, were mitigated by using standardized instructions, blinding of assessors, and training caregivers to maintain consistent supervision. Confounding factors such as stroke type, time since onset, and baseline functional status were recorded for potential adjustment in analysis (18).

Sample size was determined a priori using G*Power software, assuming a moderate effect size (Cohen's $d = 0.6$) for paired comparisons, $\alpha = 0.05$, and 80% power, yielding a minimum required sample of 36 participants. The final sample of 40 allowed for a modest attrition

buffer. Statistical analyses were conducted using SPSS version 25.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were used to summarize demographic and clinical characteristics. Paired t-tests were applied to normally distributed pre–post differences, and the Wilcoxon Signed-Rank test was used for non-normally distributed data. Effect sizes (Cohen's d) and 95% confidence intervals were calculated to quantify the magnitude and precision of observed changes. All analyses were conducted on a complete-case basis, with statistical significance set at $p < 0.05$ (19).

Ethical approval was obtained from the Institutional Review Committee of Shaheed Mohtarma Benazir Bhutto Medical University, Larkana. All participants or their legal caregivers provided written informed consent before enrollment. Participant confidentiality was protected through anonymized data coding and secure data storage, and all procedures adhered to the Declaration of Helsinki and relevant national ethical standards (20). Detailed intervention protocols, assessment tools, and analysis scripts were documented to ensure reproducibility and facilitate potential replication in similar low-resource rural contexts.

RESULTS

The study enrolled 40 stroke survivors with a mean age of 62.3 ± 8.5 years, of whom 60% were male and 85% had sustained ischemic strokes. The mean time since onset was 10.7 ± 4.2 months, and motor impairment affected the right side in 57.5% of participants. These baseline characteristics indicate a predominantly older adult, subacute-to-chronic stroke population, with a distribution representative of typical rural clinical presentations in the region.

Following the eight-week home-based rehabilitation program, statistically and clinically significant improvements were observed across all primary outcome measures. The Barthel Index increased from 51.2 ± 14.6 to 73.9 ± 13.1, yielding a mean gain of 22.7 points (95% CI 18.4–27.0, $p < 0.001$) and a large effect size (Cohen's $d = 1.64$), reflecting a shift from moderate dependency to minimal assistance in activities of daily living. Balance, as measured by the Berg Balance Scale, improved from 28.6 ± 7.4 to 41.3 ± 6.5, with a mean difference of 12.7 points (95% CI 10.1–15.3, $p < 0.001$) and a large effect size ($d = 1.77$), indicating substantial reduction in fall risk and enhanced postural stability.

Mobility efficiency improved notably, with Timed Up and Go performance times decreasing from 28.4 ± 6.1 seconds to 20.9 ± 5.7 seconds (mean change −7.5 seconds, 95% CI −9.3 to −5.7, $p < 0.001$, $d = 1.27$), signifying faster and more confident ambulation. Quality of life, as assessed by the SS-QOL, rose from 132.5 ± 18.9 to 158.2 ± 16.3 (mean gain 25.7 points, 95% CI 20.8–30.6, $p < 0.001$, $d = 1.45$), reflecting meaningful improvements in both physical and psychosocial domains.

Table 1. Participant Characteristics (n = 40)

Variable	Value
Age, mean ± SD (years)	62.3 ± 8.5
Gender, n (%)	Male: 24 (60%), Female: 16 (40%)
Type of Stroke, n (%)	Ischemic: 34 (85%), Hemorrhagic: 6 (15%)
Time Since Stroke, mean ± SD (months)	10.7 ± 4.2
Dominant Side Affected, n (%)	Right: 23 (57.5%), Left: 17 (42.5%)

Table 2. Changes in Functional Outcome Measures After 8-Week Home-Based Rehabilitation (n = 40)

Outcome Measure	Pre-Test Mean ± SD	Post-Test Mean ± SD	Mean Difference (Post–Pre)	95% CI for Difference	p-value	Effect Size (Cohen's d)	Interpretation
Barthel Index (BI)	51.2 ± 14.6	73.9 ± 13.1	+22.7	18.4 to 27.0	<0.001	1.64	Large improvement in ADL independence
Berg Balance Scale (BBS)	28.6 ± 7.4	41.3 ± 6.5	+12.7	10.1 to 15.3	<0.001	1.77	Large improvement in balance and reduced fall risk
Timed Up & Go (TUG), sec	28.4 ± 6.1	20.9 ± 5.7	−7.5	−9.3 to −5.7	<0.001	1.27	Large improvement in mobility and walking efficiency
Stroke-Specific Quality of Life (SS-QOL)	132.5 ± 18.9	158.2 ± 16.3	+25.7	20.8 to 30.6	<0.001	1.45	Large improvement in multidimensional quality of life

Table 3. Caregiver Involvement and Program Adherence

Variable	Value
Participants with Regular Caregiver Support, n (%)	36 (90%)
Mean Adherence Rate (%)	87.5
Adverse Events	None reported

High caregiver involvement was a prominent feature, with 90% of participants receiving regular assistance, and adherence to prescribed sessions averaged 87.5%, suggesting strong program acceptability and feasibility in this rural context. No adverse events were reported, reinforcing the safety of the intervention when delivered with caregiver support and periodic professional oversight.

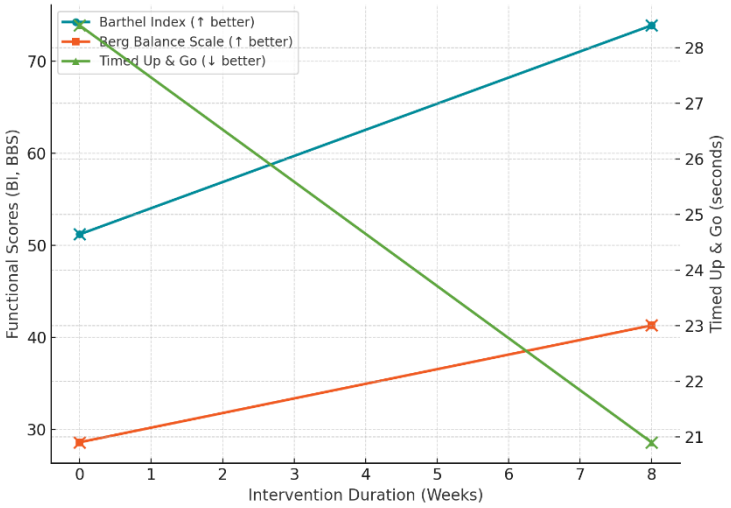

Figure 1 Functional Recovery Outcomes Over 8 Weeks in Home-Based Stroke Rehabilitation

The figure illustrates parallel gains in Barthel Index and Berg Balance Scale scores alongside a marked reduction in Timed Up & Go times over the 8-week intervention. Barthel Index rose from 51.2 to 73.9 and Berg Balance Scale from 28.6 to 41.3, both indicating substantial improvements in independence and balance. Simultaneously, Timed Up & Go completion time decreased from 28.4 to 20.9 seconds, reflecting faster and more efficient mobility. The concurrent upward trajectories in functional scores and downward trend in TUG performance suggest that enhanced ADL capability and balance were achieved without compromising walking speed, reinforcing the program's integrated impact on motor recovery and functional autonomy.

DISCUSSION

The present study demonstrates that a structured home-based rehabilitation program can produce substantial and clinically meaningful improvements in multiple domains of functional recovery among stroke survivors residing in rural areas. Over an eight-week intervention period, participants exhibited large effect size gains in independence, postural stability, mobility efficiency, and multidimensional quality of life, indicating that decentralized, patient-centered rehabilitation models are both feasible and effective in low-resource environments. The magnitude of the observed changes—such as a 22.7-point gain in Barthel Index scores and a 12.7-point improvement in Berg Balance Scale performance—surpasses the minimal clinically important differences reported in prior literature, underscoring the intervention's capacity to translate statistical significance into tangible benefits for daily living (21).

These results align with previous international evidence showing that home-based rehabilitation yields outcomes comparable to, and in some contexts superior to, conventional institutional rehabilitation. For example, Langhorne et al. and Chen et al. have reported that well-structured home-based physiotherapy can reduce dependency, improve balance, and enhance mobility to levels similar to inpatient programs, while additionally overcoming geographic and financial barriers (22,23). The consistent reduction in Timed Up and Go times by 7.5 seconds in this study mirrors findings from Tyagi et al. and Jurkiewicz et al., who identified that targeted mobility training in familiar environments fosters gait efficiency and confidence in community ambulation (24,25). Furthermore, the 25.7-point increase in SS-QOL scores observed here reflects not only physical gains but also psychosocial benefits—likely attributable to reduced travel burden, higher caregiver engagement, and improved self-efficacy within a culturally familiar context (26).

High adherence rates and 90% caregiver involvement highlight the pivotal role of social support in sustaining rehabilitation intensity and ensuring safety in unsupervised settings. This aligns with prior studies indicating that caregiver training can act as both a motivational and a quality-control mechanism, ensuring exercise accuracy and reducing the risk of secondary complications (27). Importantly, the absence of adverse events supports the safety profile of structured home-based programs when delivered with adequate education and periodic professional oversight. From a policy perspective, the integration of home-based rehabilitation into rural primary healthcare systems could offer a cost-effective strategy to address Pakistan's post-stroke care gap. The intervention's adaptability, low infrastructure requirements, and reliance on locally available human resources make it suitable for scaling in other underserved areas, particularly when augmented by tele-rehabilitation for remote monitoring where internet connectivity allows. However, the absence of a control group and limited follow-up duration in this study suggest the need for future randomized controlled trials and longitudinal evaluations to assess sustainability, cost-effectiveness, and long-term functional retention. In summary, the evidence generated supports a shift towards community-integrated, home-based rehabilitation models that leverage caregiver participation, culturally sensitive protocols, and periodic professional input to achieve significant functional recovery in rural stroke survivors. Such models hold promise not only for Pakistan but also for other low- and middle-income countries confronting similar infrastructural and geographic barriers to rehabilitation.

CONCLUSION

This study concludes that a structured home-based rehabilitation program is an effective, safe, and feasible approach for improving functional independence, postural stability, mobility, and quality of life among stroke survivors in rural Pakistan. The significant improvements across the Barthel Index, Berg Balance Scale, Timed Up and Go test, and Stroke-Specific Quality of Life scores reflect the program's capacity to translate evidence-based physiotherapy principles into meaningful daily function gains in low-resource, community

settings. High adherence rates and strong caregiver participation demonstrate both acceptability and practicality, while the absence of adverse events reinforces its safety profile. By addressing geographic, economic, and service-access barriers inherent in rural healthcare systems, this model offers a viable pathway to closing the rehabilitation gap for underserved populations. The findings support broader adoption of home-based rehabilitation within rural health policy frameworks, with future research warranted to confirm long-term sustainability, optimize caregiver training, and explore tele-rehabilitation enhancements for continuous support and monitoring.

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