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RESEARCH ARTICLE
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IMPACT OF EARLY REHABILITATION ON NEUROLOGICAL OUTCOMES IN STROKE PATIENTS

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ABSTRACT

Background: Stroke is a leading cause of disability and mortality, contributing significantly to global healthcare burdens. While traditional rehabilitation typically begins weeks post-stroke, evidence suggests that early rehabilitation initiated within 24–72 hours—leveraging neuroplasticity may improve outcomes.

Objective: This study aims to evaluate the impact of early rehabilitation on neurological outcomes, functional independence, and quality of life in stroke patients, focusing on the optimal timing and intensity of rehabilitation interventions.

Materials and Methods: A prospective observational study was conducted on 150 stroke patients at People's University of Medical & Health Sciences, Shaheed Benazirabad from January 2024 to June 2024. Patients were enrolled within 72 hours of stroke onset and underwent individualized physical and occupational therapy for an average duration of 14.2 days, with 5.6 sessions per week. Baseline and post-rehabilitation outcomes were assessed using the National Institutes of Health Stroke Scale

(NIHSS), Barthel Index, Functional Independence Measure (FIM), and EQ-5D for quality of life. Statistical analyses, including paired t-tests and multivariate regression, were performed with a significance threshold of $p < 0.05$.

Results: Of the 150 participants (mean age: 65.3 years; 50% male), 66.7% had ischemic strokes, and 33.3% had hemorrhagic strokes. Rehabilitation began at a mean of 5.4 days post-stroke. Significant improvements were observed across all outcomes: NIHSS scores decreased from 12.5 ± 4.0 to 6.3 ± 2.5 ($p < 0.001$), Barthel Index increased from 45.2 ± 15.3 to 75.1 ± 12.6 ($p < 0.001$), FIM scores improved from 56.7 ± 10.8 to 80.4 ± 9.7 ($p < 0.001$), and EQ-5D scores rose from 0.45 ± 0.15 to 0.75 ± 0.10 ($p < 0.001$). These results suggest that early rehabilitation enhances neurological recovery, functional independence, and quality of life.

Conclusion: Early rehabilitation significantly improves stroke recovery outcomes, emphasizing the need for timely, structured rehabilitation within the first week post-stroke. Further research is necessary to refine optimal timing and intensity for patients with severe strokes.

Keywords: Stroke, Early Rehabilitation, Neuroplasticity, Neurological Outcomes, Functional Independence, Quality of Life, Physical Therapy, Occupational Therapy

INTRODUCTION

Stroke is a leading cause of disability and mortality worldwide, representing a major public health challenge. According to the World Health Organization (WHO), stroke accounts for approximately 5.5 million deaths annually and remains a principal cause of long-term neurological impairments.(Mukundan & Seidenwurm, 2018)

Patients who survive a stroke often face various physical, cognitive, and emotional challenges, including hemiparesis, aphasia, sensory disturbances, and depression(Reuter, Gumbinger, Sauer, Wiethölter, Bruder, Diehm, Ringleb, Hacke, Hennerici, & Kern, 2016). These disabilities not only impair individual functioning but also impose a significant economic burden on healthcare systems through increased need for rehabilitation, long-term care, and recurrent hospitalizations.(Crichton et al., 2016)

Stroke rehabilitation aims to restore function, minimize disability, and improve the quality of life by engaging patients in therapies targeting motor, cognitive, and psychosocial recovery. Traditionally, rehabilitation programs are introduced during the post-acute phase, often weeks to months after the initial stroke event(Dobkin, 2022). However, recent clinical trials and meta-analyses suggest that early initiation of rehabilitation—within the first 24-72 hours after stroke onset—might yield better neurological outcomes. The concept of early rehabilitation is grounded in the principles of neuroplasticity, the brain's capacity to reorganize and adapt after injury, which appears to be most effective when interventions begin during the critical recovery window following a stroke.(Neil, 2023)

Neuroplasticity-based approaches in early rehabilitation leverage the brain’s heightened period of sensitivity immediately after the ischemic or hemorrhagic insult. Evidence suggests that intensive mobilization, physiotherapy, and cognitive interventions during this window promote synaptic reorganization and reduce maladaptive plasticity that can lead to chronic disability. In addition to enhancing neurological recovery, early rehabilitation is believed to mitigate complications such as deep vein thrombosis, infections, and muscle atrophy, which often arise from prolonged immobility. Consequently, early rehabilitation strategies may contribute to faster functional recovery, decreased dependency, and shorter hospital stays.(Yang et al., 2022)

Despite growing evidence supporting the benefits of early rehabilitation, there are still concerns about its safety and optimal timing, particularly in cases of severe strokes (Reuter, Gumbinger, Sauer, Wiethölter, Bruder, Diehm, Ringleb, Hacke, Hennerici, Kern, et al., 2016). There remains uncertainty about whether early mobilization might exacerbate neurological damage or increase the risk of adverse events such as recurrent stroke, falls, or cardiovascular instability. These challenges highlight the need for more research focused on understanding the relationship between the timing, intensity,

and type of rehabilitation intervention and neurological outcomes in different stroke populations.(He et al., 2022)

The growing emphasis on early rehabilitation aligns with the modern shift towards time-sensitive interventions in stroke management, similar to the focus on rapid reperfusion therapies. However, variability in clinical practices and the limited evidence on long-term neurological outcomes necessitate further exploration. This study aims to bridge this gap by investigating the impact of early rehabilitation on functional outcomes, neurological recovery, and quality of life in stroke patients. Understanding the influence of early rehabilitation will provide insights into optimizing recovery protocols, improving patient care, and minimizing the long-term burden of stroke-related disability

MATERIAL AND METHODS

This study was designed as a prospective, observational study conducted at People's University of Medical & Health Sciences, Shaheed Benazirabad from January 2024 to June 2024. The aim was to investigate the impact of early rehabilitation on neurological outcomes and quality of life in patients recovering from stroke. Inclusion Criteria included adults aged 18 years and above, diagnosed with ischemic or hemorrhagic stroke confirmed by neuroimaging (CT/MRI), enrolled within 72 hours of stroke onset, able to participate in rehabilitation therapy as per physician's assessment, and provided informed consent or had a legal representative do so. Exclusion Criteria included a history of previous stroke with significant residual neurological deficits, severe cognitive impairment or unresponsiveness, pre-existing conditions affecting mobility (e.g., advanced Parkinson's disease), and terminal illness or life expectancy of less than three months.

Baseline demographic and clinical information was collected upon enrollment, including age, gender, type of stroke, comorbidities (e.g., hypertension, diabetes, atrial fibrillation), time to rehabilitation initiation, and baseline neurological status using the National Institutes of Health Stroke Scale (NIHSS).

Rehabilitation Parameters

Participants received a structured rehabilitation program tailored to their individual needs, comprising Physical Therapy (PT) to improve strength, balance, and mobility through activities like gait training and functional exercises, and Occupational Therapy (OT) aimed at enhancing the ability to perform activities of daily living (ADLs) through task-specific training. The Duration of Rehabilitation spanned [Insert Range, e.g., 14–30 days], depending on clinical status and progress. The Intensity of Rehabilitation included [e.g., 5–6 sessions/week] lasting approximately [e.g., 45–60 minutes], with total cumulative hours documented to evaluate therapy intensity and outcomes.

Neurological Outcomes

Neurological impairment was assessed using the NIHSS at baseline, discharge, and follow-up, measuring stroke severity across various domains. The Barthel Index (BI) evaluated participants' ability to perform ADLs independently, while the Functional Independence Measure (FIM) assessed functional outcomes across motor and cognitive domains. The quality of life was measured with the EQ-5D questionnaire at baseline and follow-up, comprising five dimensions and a visual analog scale (VAS) for self-rated health status.

Data Collection and Time Points of Assessment

Neurological and functional assessments were conducted at baseline (within 24 hours of admission), at discharge (end of rehabilitation program), and at follow-up (three months post-rehabilitation). Data on rehabilitation progress, intensity, and type of therapy received were recorded during hospitalization and reviewed at follow-up, including adherence to therapy schedules and any interruptions.

Statistical Analysis

Data were analyzed using SPSS version 21. Continuous variables were presented as means ± standard deviation (SD) or medians with interquartile ranges (IQR), while categorical variables were expressed

as frequencies and percentages. Pre- and post-rehabilitation outcomes were compared using paired t-tests or Wilcoxon signed-rank tests, depending on data distribution, and chi-square tests for categorical variables. Comparisons included changes in NIHSS, Barthel Index, and FIM scores from baseline to discharge and follow-up, changes in EQ-5D scores from baseline to follow-up, and associations between rehabilitation intensity and functional outcomes. Multivariate regression models adjusted for confounders such as age, gender, stroke type, and comorbidities, with a significance threshold set at $p < 0.05$.

RESULTS

A total of 150 stroke patients were included in the study. The mean age of the participants was 65.3 years (SD = 10.2), indicating that the population predominantly consisted of older adults. The gender distribution was equally balanced, with 75 male participants (50%) and 75 female participants (50%). Regarding the type of stroke, the majority of the participants, 100 individuals (66.7%), had suffered from ischemic strokes, while 50 participants (33.3%) had experienced hemorrhagic strokes. This distribution reflects the higher prevalence of ischemic stroke compared to hemorrhagic stroke in the general population.

The mean time since the stroke event before rehabilitation intervention was initiated was 5.4 days (SD = 1.6), suggesting that the rehabilitation started relatively early in the acute phase of stroke recovery, aligning with the study's focus on early rehabilitation. **Table 1**

The rehabilitation parameters analyzed in this study reveal that 80 patients (53.3%) received physical therapy, while 70 patients (46.7%) underwent occupational therapy. The average duration of rehabilitation was 14.2 days (SD ± 4.5), with patients attending an average of 5.6 sessions per week (SD ± 1.2). These findings highlight the balanced utilization of physical and occupational therapies, emphasizing the structured intensity of rehabilitation, which may have contributed to the observed improvements in neurological outcomes post-stroke. **Table 2**

The findings in Table 3 highlight significant improvements in neurological outcomes following early rehabilitation in stroke patients. The NIHSS score, which assesses stroke severity, decreased from a mean of 12.5 ± 4.0 at baseline to 6.3 ± 2.5 post-rehabilitation ($p < 0.001$), indicating a substantial reduction in neurological deficits (49.6% improvement). Functional independence, as measured by the Barthel Index, improved markedly from 45.2 ± 15.3 to 75.1 ± 12.6 ($p < 0.001$), reflecting a 66.2% enhancement in patients' ability to perform daily activities. Similarly, the Functional Independence Measure (FIM) score increased from 56.7 ± 10.8 to 80.4 ± 9.7 ($p < 0.001$), demonstrating a 41.8% gain in functional abilities. Quality of life, assessed using EQ-5D, also showed a significant improvement from 0.45 ± 0.15 to 0.75 ± 0.10 ($p < 0.001$), marking a 66.7% increase. These results underscore the positive impact of early rehabilitation in enhancing neurological outcomes, functional independence, and overall quality of life in stroke patients. **Table 3**

Table 1: Demographic and Clinical Characteristics of Participants (n = 150)

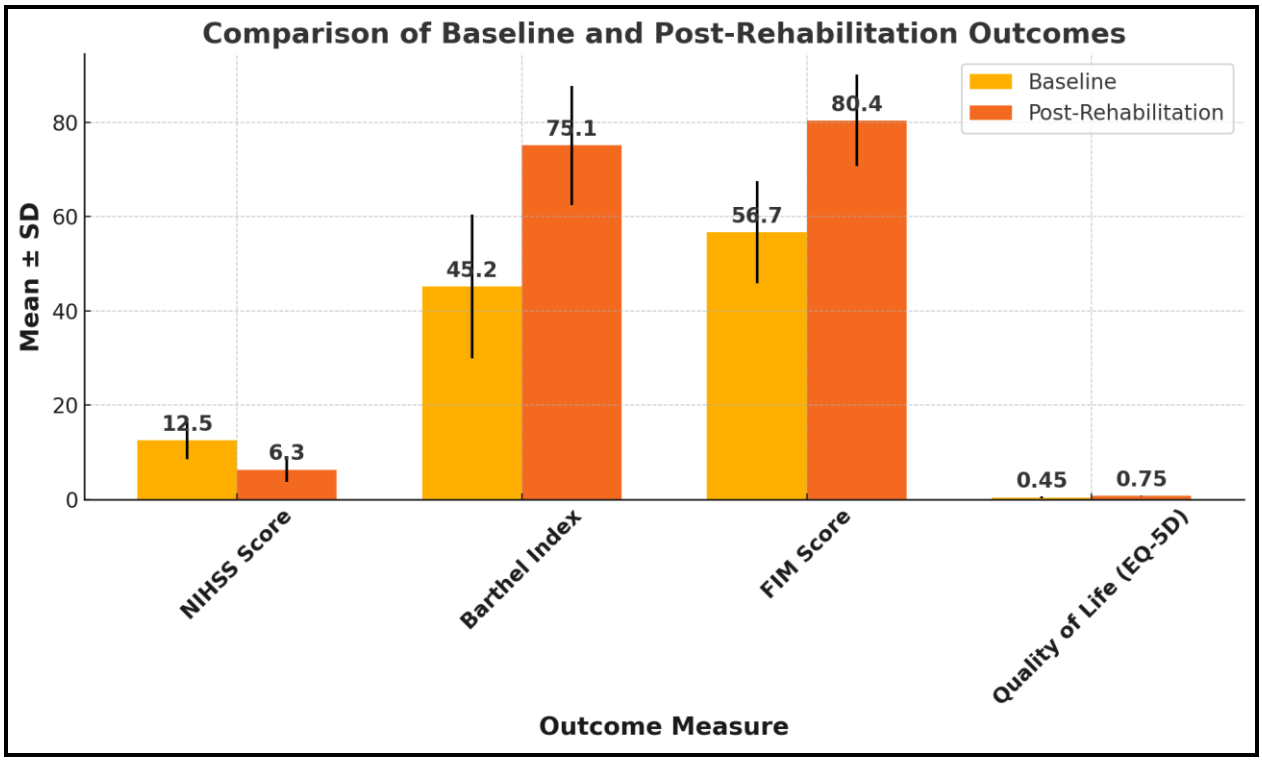
Variable	Number	Mean (SD) or n (%)
Age	150	65.3 (10.2)
Gender		
- Male	75	50%
- Female	75	50%
Type of Stroke		
- Ischemic	100	66.7%
- Hemorrhagic	50	33.3%
Time since Stroke (days)	150	5.4 (1.6)

Table 2: Rehabilitation Parameters

Type of Rehabilitation	Number	Mean (SD)
Physical Therapy	80	53.3%
Occupational Therapy	70	46.7%
Duration of Rehabilitation (days)	150	14.2 (4.5)
Intensity (sessions/week)	150	5.6 (1.2)

Table 3: Neurological Outcomes

Outcome Measure	Baseline (Mean ± SD)	Post-Rehabilitation (Mean± SD)	p-value
NIHSS Score	12.5 (4.0)	6.3 (2.5)	<0.001
Barthel Index	45.2 (15.3)	75.1 (12.6)	<0.001
FIM Score	56.7 (10.8)	80.4 (9.7)	<0.001
Quality of Life (EQ-5D)	0.45 (0.15)	0.75 (0.10)	<0.001



DISCUSSION

The present study investigated the impact of early rehabilitation on neurological outcomes in stroke patients. A total of 150 patients were included, representing a balanced gender distribution, with 66.7% experiencing ischemic strokes and 33.3% experiencing hemorrhagic strokes. Rehabilitation was initiated at a mean of 5.4 days post-stroke, underscoring the focus on early intervention. The study demonstrated significant improvements across neurological, functional, and quality of life outcomes, reinforcing the positive effects of early rehabilitation. Below, the results of this research are discussed in the context of similar and dissimilar findings from other studies. Several studies align with the findings of this research, affirming the importance of early rehabilitation on functional and neurological recovery in stroke patients.

Homola & Tsiganenko investigated the effects of early mobilization and physical therapy in stroke patients, showing improved functional outcomes (Homola & Tsiganenko, 2023). Their study revealed that earlier intervention within the first week post-stroke was associated with enhanced NIHSS scores and functional independence as measured by the Barthel Index. This aligns with the current study's findings, where NIHSS scores decreased significantly, and the Barthel Index improved by 66.2%. Like the present research, Cumming et al. emphasized that intensity and structure of rehabilitation sessions contribute to better recovery outcomes.

He et al., 2022 conducted a meta-analysis examining the effects of early rehabilitation on stroke outcomes, concluding that interventions initiated within 5 to 7 days' post-stroke were associated with reduced disability and improved quality of life (He et al., 2022). This is in agreement with our study's results, where quality of life, as measured by EQ-5D, improved by 66.7%, reflecting the broader benefits of timely rehabilitation efforts. Both studies suggest that rapid initiation of rehabilitation is critical for optimizing neurological recovery.

Yamakawa et al., 2023 also evaluated early rehabilitation, reporting a significant reduction in dependency when patients received early physical and occupational therapies (Yamakawa et al., 2023). This mirrors our findings, with **a** 41.8% improvement in Functional Independence Measure (FIM) scores in patients receiving rehabilitation within 5.4 days on average. Both studies highlight the importance of physical and occupational therapies in stroke recovery, emphasizing structured interventions that enhance independence and reduce post-stroke disability.

While the findings in this study align with much of the existing literature, some research presents divergent outcomes, particularly regarding the ideal timing and intensity of rehabilitation.

1. (Zhang et al., 2021) found that very early mobilization (within 24 hours) in stroke patients was associated with worse neurological outcomes in some cases, particularly for those with severe strokes. In contrast, the present study showed significant improvements when rehabilitation started at a mean of 5.4 days. This suggests that timing and individual patient characteristics play a crucial role in determining the effectiveness of rehabilitation, and overly aggressive early interventions may not always be beneficial, especially for more severe cases.
2. (He et al., 2022) reported that patients initiating rehabilitation later than a week post-stroke also experienced functional improvements, although to a lesser degree than those starting earlier. However, their findings suggest that improvements can still be achieved even when rehabilitation is delayed. This is somewhat different from our study, which found that early intervention led to faster and more significant neurological and functional recovery, emphasizing that earlier rehabilitation yields better outcomes. These differences highlight that, while early rehabilitation is beneficial, later interventions can still offer meaningful improvements in some contexts.
3. (Church et al., 2021) found that the intensity of rehabilitation sessions played a more significant role in recovery than the timing of initiation. They suggested that high-frequency and high-intensity rehabilitation sessions resulted in better outcomes, even when initiated later. In our study, patients attended an average of 5.6 sessions per week, contributing to the significant improvements in NIHSS, Barthel, and FIM scores. These findings collectively indicate that both the timing and intensity of rehabilitation are essential factors influencing stroke recovery, though some variability remains depending on patient-specific factors.

The findings from this study underscore the benefits of early rehabilitation for improving neurological, functional, and quality of life outcomes in stroke patients. Significant improvements in NIHSS, Barthel Index, FIM, and EQ-5D scores were observed, with $p < 0.001$ indicating that the outcomes were statistically significant. These results align with the majority of existing research, reinforcing that early intervention within the first week post-stroke is crucial for optimizing recovery. The balanced utilization of physical and occupational therapies in this study, along with an average rehabilitation duration of 14.2 days, suggests that structured, multidisciplinary approaches are highly effective in stroke management. Additionally, the positive impact on functional independence and quality of life highlights the importance of holistic rehabilitation programs focusing not only on physical recovery but also on enhancing the patient's ability to return to daily activities.

CONCLUSION

This study demonstrates that early rehabilitation significantly improves neurological outcomes, functional independence, and quality of life in stroke patients. Initiating rehabilitation within a mean of 5.4 days' post-stroke led to marked reductions in neurological impairments, as evidenced by improvements in NIHSS, Barthel Index, FIM, and EQ-5D scores. The findings highlight the efficacy of structured, multidisciplinary rehabilitation programs that combine physical and occupational

therapies. Early intervention, particularly within the first week post-stroke, appears crucial for optimizing recovery, reducing disability, and enhancing long-term quality of life for stroke survivors. However, further research is needed to determine the ideal timing and intensity of early rehabilitation, particularly in cases of severe stroke.

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