

OPTIMIZING FUNCTIONAL RECOVERY AFTER STROKE THROUGH EARLY NEUROLOGICAL REHABILITATION : AN EVIDENCE BASED LITERATURE REVIEW

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ABSTRAK

Stroke tetap menjadi salah satu penyebab utama kecacatan jangka panjang di seluruh dunia, secara signifikan memengaruhi fungsi motorik, sensorik, kognitif, dan psikososial, serta menimbulkan beban yang besar bagi pasien, keluarga, dan sistem perawatan kesehatan. Rehabilitasi neurologis dini semakin diakui sebagai strategi penting untuk mengoptimalkan pemulihan fungsional setelah stroke dengan memanfaatkan kapasitas neuroplastisitas otak yang meningkat selama fase akut dan subakut awal. Tinjauan literatur ini bertujuan untuk mensintesis dan menganalisis secara kritis bukti terkini mengenai efektivitas rehabilitasi neurologis dini dalam meningkatkan hasil fungsional setelah stroke. Tinjauan komprehensif terhadap studi yang ditinjau sejawat yang diterbitkan dalam beberapa tahun terakhir dilakukan, dengan fokus pada intervensi rehabilitasi yang dimulai dalam fase akut dan subakut stroke. Tinjauan tersebut mencakup studi yang meneliti pendekatan multidisiplin seperti fisioterapi, terapi okupasi, terapi bicara dan bahasa, dan pelatihan berorientasi tugas. Temuan menunjukkan bahwa rehabilitasi neurologis dini, terstruktur, dan individual berkontribusi pada peningkatan pemulihan motorik, peningkatan kinerja dalam aktivitas kehidupan sehari-hari, pengurangan komplikasi sekunder, masa rawat inap yang lebih pendek, dan kualitas hidup secara keseluruhan yang lebih baik. Lebih lanjut, rehabilitasi dini dikaitkan dengan peningkatan reorganisasi neurologis dan kemandirian fungsional jangka panjang. Tinjauan ini mendukung implementasi rehabilitasi neurologis dini sebagai komponen integral dan berbasis bukti dari manajemen stroke untuk memaksimalkan pemulihan fungsional dan hasil jangka panjang pada penyintas stroke.

Kata kunci : neuroplastisitas, pemulihan fungsional, rehabilitasi neurologis dini, rehabilitasi multidisiplin, stroke

ABSTRACT

Stroke remains one of the leading causes of long term disability worldwide, significantly affecting motor, sensory, cognitive, and psychosocial functions, and imposing a substantial burden on patients, families, and healthcare systems. Early neurological rehabilitation has been increasingly recognized as a critical strategy to optimize functional recovery following stroke by utilizing the brain's heightened capacity for neuroplasticity during the acute and early subacute phases. This literature review aims to synthesize and critically analyze current evidence regarding the effectiveness of early neurological rehabilitation in improving functional outcomes after stroke. A comprehensive review of peer reviewed studies published in recent years was conducted, focusing on rehabilitation interventions initiated within the acute and subacute phases of stroke. The review included studies examining multidisciplinary approaches such as physiotherapy, occupational therapy, speech and language therapy, and task oriented training. The findings indicate that early, structured, and individualized neurological rehabilitation contributes to improved motor recovery, enhanced performance in activities of daily living, reduced secondary complications, shorter hospital stays, and better overall quality of life. Furthermore, early rehabilitation is associated with improved neurological reorganization and long term functional independence. This review supports the implementation of early neurological rehabilitation as an evidence based and integral component of stroke management to maximize functional recovery and long term outcomes in stroke survivors.

Keywords : stroke, early neurological rehabilitation, functional recovery, neuroplasticity; multidisciplinary rehabilitation

INTRODUCTION

Stroke is a major public health problem and remains one of the leading causes of mortality and long term disability worldwide. Global epidemiological data indicate that millions of people experience stroke annually, with a substantial proportion surviving due to advances in acute medical management. However, survival often comes with persistent neurological impairments that significantly affect daily functioning. These impairments place a heavy burden not only on individuals but also on families, caregivers, and healthcare systems. The increasing life expectancy of the global population has contributed to a growing number of stroke survivors living with chronic disabilities. As a result, stroke related disability has become a major contributor to years lived with disability worldwide. Stroke survivors frequently present with a wide spectrum of neurological deficits. Common impairments include motor weakness, impaired balance and coordination, sensory disturbances, speech and language disorders, and cognitive dysfunction. Emotional and psychological disturbances such as depression, anxiety, and reduced motivation are also prevalent. Together, these deficits significantly reduce independence and quality of life. Functional limitations following stroke often restrict an individual's ability to perform activities of daily living independently. Tasks such as walking, dressing, eating, and communication may become challenging or impossible without assistance.

Without appropriate rehabilitation, functional recovery after stroke is often incomplete. Delayed or inadequate intervention may lead to long term disability, reduced functional gains, and increased healthcare utilization. Prolonged immobility can exacerbate physical impairments and contribute to additional complications. Therefore, timely rehabilitation is essential to support recovery and prevent further decline. Historically, stroke rehabilitation was initiated only after complete medical stabilization. This approach often resulted in rehabilitation being delayed for weeks after stroke onset. Over the past two decades, this traditional paradigm has been increasingly challenged. Accumulating evidence suggests that early neurological rehabilitation can be safely implemented in selected patients. Studies have demonstrated that early intervention may lead to better functional outcomes compared to delayed rehabilitation. This shift in understanding has led to growing interest in early rehabilitation strategies. Early neurological rehabilitation refers to the initiation of structured rehabilitation interventions during the acute and early subacute phases of stroke. These phases typically encompass the first days to weeks following stroke onset. Interventions may include early mobilization, task specific motor training, positioning strategies, and cognitive and communication therapies.

One of the primary objectives of early rehabilitation is to minimize disability and functional decline. By engaging patients in therapeutic activities early, clinicians aim to prevent learned non use and deconditioning. Early rehabilitation also seeks to maintain joint mobility, muscle strength, and cardiovascular endurance. These factors are crucial for long term functional independence. The scientific foundation of early neurological rehabilitation is strongly linked to the concept of neuroplasticity. Neuroplasticity refers to the brain's ability to reorganize neural pathways in response to injury and experience. Research indicates that neuroplasticity is most pronounced during the early post stroke period. During this time, neural circuits are particularly responsive to external stimulation and training. Rehabilitation interventions delivered within this critical window can enhance cortical reorganization. This process facilitates the relearning of motor and cognitive functions. Early rehabilitation interventions are designed to harness this period of heightened plasticity. Repetitive, goal-oriented activities stimulate neural networks involved in movement and function. Task specific training encourages the formation of new synaptic connections. These mechanisms support functional re learning and recovery. In addition to promoting neurological recovery, early

rehabilitation plays a vital role in preventing secondary complications. Prolonged bed rest after stroke increases the risk of muscle atrophy and joint contractures. Patients are also vulnerable to pressure ulcers, deep vein thrombosis.

Psychological complications are also common in stroke patients who experience prolonged inactivity. Depression, anxiety, and reduced motivation can negatively affect rehabilitation engagement. Early participation in rehabilitation activities has been associated with improved mood and psychological well being. Addressing mental health early supports sustained recovery. Early neurological rehabilitation also contributes to improved cardiovascular and respiratory function. Gentle mobilization and exercise enhance circulation and oxygenation. These physiological benefits support overall health and reduce the risk of secondary medical complications. Improved physical conditioning facilitates participation in more intensive rehabilitation later. A multidisciplinary approach is widely recognized as a cornerstone of effective early neurological rehabilitation. Stroke related impairments are complex and multifaceted, requiring input from multiple healthcare professionals. Physiotherapists focus on restoring mobility, balance, and strength through targeted exercises. Occupational therapists address functional independence and activities of daily living. Speech language therapists manage communication and swallowing disorders. Together, these disciplines address the diverse needs of stroke survivors. Individualization of rehabilitation programs is essential in early neurological rehabilitation. Stroke severity, patient tolerance, comorbidities, and cognitive status must be carefully considered.

Despite growing evidence supporting early rehabilitation, variations in clinical practice remain. Differences in healthcare resources, staffing, and rehabilitation infrastructure influence implementation. In some settings, access to early rehabilitation services may be limited. These disparities highlight the need for evidence based guidelines. Given the expanding body of research on early neurological rehabilitation, synthesizing current evidence is essential. A comprehensive understanding of its effectiveness can inform clinical decision making and policy development. Literature reviews play a critical role in summarizing existing knowledge. They also identify gaps for future research. Therefore, this literature review aims to examine and synthesize current evidence on early neurological rehabilitation after stroke. The focus is on functional recovery, neuroplastic mechanisms, and multidisciplinary intervention strategies. By summarizing available findings, this review seeks to support evidence based practice. Ultimately, optimizing early rehabilitation may improve long term outcomes for stroke survivors.

METHOD

To enhance the rigor of the literature selection process, a stepwise screening method was applied. Initially, titles and abstracts of all retrieved articles were screened to assess relevance to the research objective. Articles that clearly did not address early neurological rehabilitation or functional recovery after stroke were excluded at this stage. The remaining studies underwent full text review to determine eligibility based on predefined inclusion and exclusion criteria. This systematic screening helped minimize selection bias. Quality appraisal of the included studies was conducted to ensure the reliability of the evidence synthesized. Studies were evaluated based on methodological clarity, appropriateness of study design, sample size adequacy, and validity of outcome measures. Randomized controlled trials and systematic reviews were given greater weight due to their higher level of evidence. This appraisal process supported balanced interpretation of findings across studies.

Data extraction was performed using a standardized framework to ensure consistency. Extracted information included authorship, year of publication, study design, sample characteristics, type of stroke, rehabilitation interventions, timing of rehabilitation initiation,

and reported outcomes. Functional outcomes were prioritized, particularly motor recovery, independence in activities of daily living, and quality of life measures. This structured approach facilitated comparison across studies. A narrative synthesis method was selected due to heterogeneity among the included studies. Variations in rehabilitation protocols, intervention intensity, outcome measures, and follow up duration limited the feasibility of quantitative meta analysis. Narrative synthesis allowed for a comprehensive description of trends, similarities, and differences across studies. This method also enabled integration of both clinical and mechanistic evidence. Ethical considerations were addressed by ensuring that all included studies were previously approved by relevant institutional review boards, as reported by the original authors. As this study was a literature review, no direct involvement of human participants occurred. Therefore, formal ethical approval was not required. However, ethical integrity was maintained by accurately representing original findings and avoiding data misinterpretation.

RESULTS

The reviewed literature consistently demonstrates that early neurological rehabilitation is strongly associated with improved functional outcomes in patients following stroke. Stroke related impairments often lead to long term disability, making timely rehabilitation a critical component of recovery. Studies across various research designs highlight that patients receiving early intervention experience faster functional gains. Compared with delayed rehabilitation, early programs reduce long term dependence. These findings emphasize the importance of early rehabilitation in stroke management. Evidence from randomized controlled trials, cohort studies, and systematic reviews shows that early rehabilitation accelerates recovery processes. Patients who begin rehabilitation during the acute or early subacute phase tend to show better functional trajectories. Early intervention facilitates faster improvement in motor performance and daily functioning. These improvements are sustained over time and contribute to long term independence. Thus, early rehabilitation provides both short and long term benefits.

Motor recovery is one of the most frequently reported benefits of early neurological rehabilitation. Stroke commonly results in muscle weakness and impaired coordination, limiting functional movement. Early therapeutic exercises help preserve muscle strength and joint mobility. These interventions also reduce the risk of secondary complications caused by immobility. Consequently, patients demonstrate improved motor outcomes. Early mobilization plays a central role in neurological rehabilitation during the acute phase. Mobilization initiated within the first 24 to 72 hours after stroke has been shown to be safe for medically stable patients. Activities such as assisted sitting, standing, and walking promote postural control. These exercises enhance balance and coordination. Early mobilization also prevents complications associated with prolonged bed rest. Task specific training is another effective strategy used in early stroke rehabilitation. This approach emphasizes repetitive practice of meaningful functional tasks. Repetition strengthens neural pathways involved in motor control. Patients receiving task specific training demonstrate better upper and lower limb function. As a result, functional movement patterns are restored more effectively.

Table 1. Motor and Functional Outcomes of Early Neurological Rehabilitation

Intervention type	Phase of Stroke	Main Functional Outcomes	Clinical Implications
Early mobilization	Acute phase (24–72 hours)	Improved strength and balance	Faster mobility recovery
Task specific training	Acute–early subacute phase	Upper and lower limb motor recovery	Improved functional performance
Gait training	Early subacute phase	Walking ability and endurance	Independent ambulation

Recovery of walking ability is a key outcome emphasized in the literature. Early gait training improves walking speed, endurance, and balance. Patients who begin gait training early are more likely to regain independent ambulation. Improved walking ability enhances confidence and reduces fall risk. Mobility recovery also supports social participation. In addition to motor improvements, early rehabilitation positively affects activities of daily living. Occupational therapy interventions focus on essential self care tasks such as dressing, feeding, and hygiene. Early engagement in these activities promotes functional independence. Patients become less reliant on caregivers during recovery. These improvements enhance quality of life.

Occupational therapy also introduces adaptive strategies to compensate for residual impairments. Environmental modifications and assistive devices are introduced early. This approach allows patients to remain active despite limitations. Studies report improved ADL scores at discharge among patients receiving early therapy. These benefits often persist beyond hospitalization. Speech and language rehabilitation initiated early after stroke improves communication outcomes. Patients with aphasia or dysarthria benefit from early intervention targeting speech production and comprehension. Early therapy helps preserve language abilities. Improved communication supports emotional wellbeing and social interaction. This contributes significantly to overall recovery. Swallowing disorders are common following stroke and increase the risk of aspiration. Early assessment and therapy for dysphagia reduce complications such as pneumonia. Patients receiving early swallowing therapy demonstrate improved oral intake. Adequate nutrition and hydration are better maintained. This supports overall medical stability.

Table 2. Multidisciplinary Early Rehabilitation and Associated Outcomes

Discipline Involved	Focus of Intervention	Reported Outcomes	Patient Benefits
Physiotherapy	Mobility and balance training	Improved motor function	Reduced fall risk
Occupational therapy	Activities of daily living	Increased independence	Better self-care ability
Speech-language therapy	Communication and swallowing	Improved speech and feeding	Social participation
Multidisciplinary team	Integrated functional care	Global functional improvement	Shorter hospital stay

Early cognitive rehabilitation has also been shown to improve attention, memory, and executive function. Cognitive impairments often interfere with rehabilitation participation. Early stimulation helps maintain cognitive engagement. Patients demonstrate improved problem solving abilities. These improvements support functional recovery. Psychological benefits are another important outcome of early rehabilitation. Depression and anxiety are common after stroke and negatively affect recovery. Early therapeutic engagement enhances motivation and emotional well being. Structured rehabilitation provides patients with a sense of purpose. This supports long term adherence to therapy. Family involvement during early rehabilitation positively influences recovery outcomes. Caregiver education improves continuity of care after discharge. Families assist with exercises and daily activities at home. Emotional support from caregivers enhances patient confidence. This collaborative approach improves overall recovery.

DISCUSSION

A multidisciplinary rehabilitation approach is widely recognized as essential. Collaboration among healthcare professionals ensures comprehensive care. Each discipline addresses specific impairments related to stroke. Coordinated intervention plans improve efficiency. This model leads to better functional outcomes. Early multidisciplinary

rehabilitation is associated with shorter hospital stays. Patients reach functional milestones more rapidly. Early discharge reduces hospital related complications. Transition to community or outpatient rehabilitation becomes smoother. These benefits are advantageous for both patients and healthcare systems. From an economic perspective, early rehabilitation reduces healthcare costs. Shorter hospitalizations and fewer complications lower overall expenses. Reduced long-term disability decreases the need for institutional care. These cost savings benefit healthcare systems. Early rehabilitation is therefore cost effective.

Neurologically, early rehabilitation supports cortical reorganization and synaptic plasticity. The post-stroke brain exhibits heightened plasticity during the early phase. Repetitive and goal oriented activities stimulate neural adaptation. New neural pathways compensate for damaged areas. This enhances functional recovery. Neuroimaging studies provide biological evidence supporting early intervention. Increased activation is observed in motor related brain regions. These changes correlate with improved motor performance. Both ipsilesional and contralesional hemispheres are involved. This confirms the neurological basis of recovery. Despite its benefits, early rehabilitation must be individualized. Not all patients tolerate high intensity therapy in the acute phase. Excessive intensity may cause fatigue or instability. Careful assessment is essential. Safety remains a primary concern. Clinical decision making should consider stroke severity and comorbidities. Continuous monitoring ensures appropriate therapy progression. Rehabilitation intensity should be adjusted as recovery progresses. Individualized programs optimize outcomes. This approach minimizes risks.

Variability in rehabilitation protocols remains a challenge in research. Differences in intervention type and intensity limit comparison. Outcome measures also vary across studies. Standardized guidelines are needed. Future research should address these inconsistencies. Access to early rehabilitation services remains unequal globally. Resource limitations affect service availability in many regions. Shortages of trained professionals delay intervention. These disparities impact patient outcomes. Global strategies are needed to improve access. Delayed referral systems further hinder early rehabilitation. Lack of awareness among healthcare providers contributes to delays. Education and protocol development can improve referral timing. Early identification of eligible patients is essential. System level improvements are required. Integration of rehabilitation into acute stroke care is strongly recommended. Rehabilitation should begin alongside medical treatment. This ensures continuity of care. Early integration improves outcomes. It reflects a modern approach to stroke management.

Technological advancements are increasingly incorporated into early rehabilitation. Robotic-assisted therapy and virtual reality enhance training intensity. These tools provide safe and repetitive practice. Patient motivation is often increased. Technology supports innovative rehabilitation strategies. Tele rehabilitation is emerging as a complementary approach. Remote therapy improves access for patients with limited resources. It allows continuity of care after discharge. Preliminary studies show promising results. Further research is needed to validate effectiveness. Outcome evaluation should adopt a holistic perspective. Recovery involves physical, cognitive, and psychosocial domains. Quality of life measures are essential. Comprehensive assessment reflects true recovery. This aligns with patient centered care. Patient engagement is crucial in rehabilitation success. Involving patients in goal setting increases motivation. Active participation improves adherence to therapy. Patients feel empowered in their recovery process. This leads to better outcomes. Health policies play a significant role in rehabilitation implementation. Supportive policies ensure adequate funding and staffing. National guidelines promote standardized care. Policy commitment improves service availability. This benefits stroke survivors. Overall, evidence strongly supports early neurological rehabilitation as a key determinant of recovery. Benefits extend across functional domains. Multidisciplinary and individualized approaches enhance effectiveness. Timing of intervention is critical. Early rehabilitation should be prioritized.

CONCLUSION

Early neurological rehabilitation is a key determinant of functional recovery after stroke and represents a fundamental component of comprehensive stroke management. Evidence from the literature consistently indicates that initiating rehabilitation interventions during the acute and early subacute phases leads to superior functional outcomes compared to delayed rehabilitation. Early intervention allows patients to take advantage of the brain's heightened neuroplastic potential, thereby promoting more effective recovery processes. Improvements in motor function are among the most prominent benefits of early neurological rehabilitation. Early mobilization, task specific training, and repetitive practice contribute to better muscle strength, coordination, balance, and gait performance. These improvements are crucial for restoring basic mobility and enabling patients to regain independence in daily activities.

Beyond motor recovery, early rehabilitation plays a significant role in enhancing functional independence. Interventions targeting activities of daily living, communication, and cognitive function allow stroke survivors to participate more actively in self care and social interactions. As a result, patients experience improved autonomy and reduced dependence on caregivers. Psychological and emotional well being are also positively influenced by early neurological rehabilitation. Early engagement in structured rehabilitation programs has been associated with reduced levels of post stroke depression and anxiety, increased motivation, and better overall adjustment to disability. These psychosocial factors are essential for sustaining long-term rehabilitation engagement and recovery. The literature emphasizes that an individualized and multidisciplinary rehabilitation approach is essential to maximize recovery potential. Collaboration among healthcare professionals ensures that physical, cognitive, communicative, and emotional impairments are addressed holistically. Tailoring rehabilitation intensity and content to individual patient needs enhances safety and effectiveness. From a healthcare system perspective, early neurological rehabilitation contributes to shorter hospital stays, reduced complication rates, and lower long term healthcare costs.

Despite strong evidence supporting early rehabilitation, variability in intervention protocols and limited access to rehabilitation services remain challenges. Differences in healthcare resources, clinical expertise, and rehabilitation infrastructure may influence the timing and quality of rehabilitation delivery, especially in low and middle income settings. Future research should focus on optimizing the timing, intensity, and specific components of early neurological rehabilitation to further improve outcomes for stroke survivors. High quality randomized controlled trials and standardized clinical guidelines are needed to refine best practices and ensure equitable access to effective early rehabilitation worldwide.

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