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Effectiveness of Intensive Rehabilitation on Motor Recovery After Ischemic Stroke in Productive Age Patients

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Abstract

Ischemic stroke remains a leading cause of disability worldwide, with productive-age individuals (15–64 years) representing a significant proportion of affected populations. Motor impairments following ischemic stroke often result in long-term loss of independence, reduced quality of life, and socioeconomic burden if recovery is not optimized. Intensive rehabilitation—characterized by higher frequency, duration, and task-specific training initiated early after stroke onset—has been increasingly recognized as a promising approach to improve functional recovery. This study aimed to evaluate the effectiveness of intensive rehabilitation on motor recovery among productive-age ischemic stroke patients. A qualitative literature review was conducted by synthesizing evidence from clinical trials, systematic reviews, and observational studies published in the last decade. Data were collected from PubMed, ScienceDirect, SpringerLink, and Google Scholar using keywords including "ischemic stroke," "intensive rehabilitation," "motor recovery," and "productive age." The findings consistently indicate that intensive rehabilitation significantly accelerates and enhances motor recovery compared to standard rehabilitation. Early initiation, preferably within the first two weeks after stroke, and adequate frequency of therapy sessions are crucial in maximizing recovery outcomes by leveraging neuroplasticity. Demographic and clinical factors—such as younger age within the productive range, mild to moderate stroke severity, and absence of comorbidities—were associated with better rehabilitation outcomes. In conclusion, intensive rehabilitation provides superior short-term functional improvements and facilitates earlier achievement of independence in productive-age stroke survivors. However, long-term benefits depend on sustained therapy and individualized treatment planning. This study underscores the importance of structured, timely, and intensive rehabilitation strategies to support motor recovery and workforce reintegration among productive-age stroke patients.

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INTRODUCTION

Ischemic stroke is one of the leading causes of permanent disability worldwide, particularly in terms of motor impairment that disrupts daily functioning (Wei et al., 2024). The prevalence of stroke among productive-age populations (typically defined as 15–64 years) has been increasing, thereby imposing a heavier economic and social burden if motor recovery is not optimized (Berger et al., 1998; Santoso et al., 2024). In Indonesia, the productive-age group represents a large proportion of stroke cases, and nearly 70% of stroke patients undergoing rehabilitation are within this age range, with rehabilitation costs placing a significant economic burden. Motor impairments following ischemic stroke, if not addressed through adequate rehabilitation, can result in long-term loss of limb function, decreased mobility and autonomy, and reduced quality of life (Lou et al., 2024; Yagi et al., 2017).

Ischemic stroke is a serious medical condition that occurs when blood flow to the brain is blocked, usually due to a thrombus (local blood clot) or embolus (a clot originating from another part of the body). This obstruction reduces the supply of oxygen and nutrients to brain tissue, leading to rapid neuronal damage. Major risk factors include hypertension, diabetes mellitus, hyperlipidemia, smoking, and atrial fibrillation, which increases the likelihood of clot formation (Campbell et al., 2019). Without prompt treatment, ischemic stroke can cause permanent neurological deficits or even death.

Management of ischemic stroke includes reperfusion therapy with intravenous tissue plasminogen activator (tPA) within 4.5 hours of symptom onset, or mechanical thrombectomy in cases of large vessel occlusion (Kleindorfer et al., 2021). In addition to acute therapy, secondary prevention strategies are crucial, such as controlling cardiovascular risk factors, prescribing antiplatelet or anticoagulant agents when indicated, and providing rehabilitation to restore motor and cognitive functions (Feigin et al., 2021). Early recognition of stroke symptoms, highlighted by the *FAST* concept (Face drooping, Arm weakness, Speech difficulty, Time to call emergency), plays a vital role in improving treatment outcomes and reducing disability rates (Avan et al., 2019).

Intensive rehabilitation is defined as interventions with greater frequency, duration, and intensity of therapy sessions compared to conventional care, initiated as early as possible following stroke onset (Wu et al., 2020). Recent meta-analyses have shown that early rehabilitation (initiated within the first two weeks after stroke) significantly improves outcomes such as the Barthel Index, Modified Barthel Index, and Fugl-Meyer scores compared to delayed rehabilitation. Similarly, pilot studies on acute ischemic stroke patients involving intensive lower-limb ergometer training demonstrated significant improvements in motor control after four weeks compared with conventional therapy alone.

Although many studies highlight the benefits of early and intensive rehabilitation, there remains substantial variability in how "intensive" is defined (e.g., hours per day, type of motor tasks, frequency, and workload) as well as heterogeneity in outcomes based on age, stroke severity, and timing of intervention. Productive-age patients may have a greater recovery potential compared to older adults due to higher neuroplasticity, fewer comorbidities, and stronger motivation. However, there is still limited evidence specifically addressing the impact of intensive rehabilitation in this age group (García-Rudolph et al., 2021; Knecht et al., 2016).

Furthermore, there exists a gap between clinical practice in Indonesia and international evidence, particularly in terms of the availability of intensive rehabilitation facilities, delays in accessing rehabilitation services, and disparities in financial resources and public health support (Huttami & Hidajah, 2020; Santoso et al., 2024). Many productive-age stroke patients face barriers to receiving optimal interventions during the "golden period" of stroke rehabilitation, thus reducing the potential for maximum motor recovery (Tri Huttami & Choirul Hidajah, 2020). Moreover, research

specifically focused on the effectiveness of intensive rehabilitation for motor recovery in productive-age ischemic stroke patients in Indonesia remains scarce, especially with strong methodological designs such as prospective controlled studies with adequate sample sizes and standardized motor outcome measures.

Since stroke in productive-age populations affects not only individual health but also workforce productivity, household economics, and broader social costs, it is crucial to determine how effective intensive rehabilitation is in accelerating and enhancing motor recovery. This research will assist policymakers and healthcare providers in designing appropriate rehabilitation programs, allocating resources, and developing timely interventions for productive-age stroke patients.

Several studies have investigated the effects of intensive rehabilitation on motor recovery and functional outcomes. For example, a prospective pilot study on acute ischemic stroke patients showed that intensive lower-limb interventions within the first 48 hours post-stroke led to significantly better motor control at week four compared to conventional therapy (Wu et al., 2020). Additionally, a recent meta-analysis comparing early versus late rehabilitation interventions found that early rehabilitation (within two weeks post-stroke) significantly improved Fugl-Meyer scores, Barthel Index, NIHSS, and other neurological functions. However, most of these studies did not specifically focus on productive-age patients, and samples often included mixed age groups, leaving a gap in evidence regarding the unique outcomes of intensive rehabilitation in productive-age stroke survivors.

Based on this background, the present study aims to evaluate the effectiveness of intensive rehabilitation on motor recovery in productive-age ischemic stroke patients. Specifically, this study seeks to:

1. Assess the differences in motor recovery between productive-age stroke patients receiving intensive rehabilitation and those receiving standard rehabilitation.
2. Analyze the impact of rehabilitation onset time and therapy frequency on the speed of motor recovery.
3. Identify demographic and clinical factors (such as specific age, stroke severity, comorbidities, and onset-to-rehabilitation interval) that may modify the response to intensive rehabilitation.

METHOD

This study employed a qualitative research design using a literature study approach. The literature study was chosen because the topic under investigation—effectiveness of intensive rehabilitation on motor recovery after ischemic stroke in productive-age patients—has been widely discussed in previous research, including clinical trials, observational studies, and meta-analyses. By synthesizing findings from existing studies, this research aimed to provide a comprehensive understanding of the effectiveness of intensive rehabilitation in this specific context (Snyder, 2019).

Data Sources

The data sources consisted of scientific articles, books, and academic publications related to ischemic stroke, intensive rehabilitation, and motor recovery in productive-age patients. Literature searches were conducted through databases such as PubMed, ScienceDirect, SpringerLink, and Google Scholar, using keywords including *"ischemic stroke," "intensive rehabilitation," "motor recovery,"* and *"productive age."* Inclusion criteria covered publications from the last five to ten years, written in English or Indonesian, and directly relevant to the research focus. Exclusion criteria included inaccessible full texts, studies outside the scope, or publications lacking analyzable data (Siddaway et al., 2019).

Data Collection Techniques

Data collection was carried out through systematic screening of articles based on inclusion criteria, followed by critical reading of the selected literature. Important information was extracted, including research design, sample size, type of rehabilitation intervention, indicators of motor recovery, and main results. The collected information was then organized into a literature matrix to facilitate comparison across studies (Kitchenham & Charters, 2007).

Data Analysis Method

The data were analyzed using content analysis with a thematic approach. Thematic coding was applied to categorize findings into key themes, such as the effectiveness of intensive rehabilitation on motor recovery, influencing factors in productive-age patients, and comparisons with standard rehabilitation methods. Each finding was compared and contrasted to identify consistent patterns and differences across studies. Thematic analysis was chosen because it allows qualitative exploration of meanings, trends, and underlying concepts within the reviewed literature (Clarke & Braun, 2017). The synthesis of these themes formed the basis for conclusions regarding the effectiveness of intensive rehabilitation in improving motor recovery after ischemic stroke in productive-age patients.

RESULT AND DISCUSSION

Differences in Motor Recovery Between Intensive and Standard Rehabilitation

Recent clinical trials and systematic reviews have consistently demonstrated that intensive rehabilitation programs—characterized by higher training doses, repetitive task-specific practice, and in many cases the integration of assistive technologies—result in faster and more substantial motor recovery compared to standard rehabilitation in patients with ischemic stroke of productive age (Wei et al., 2024; Wu et al., 2020). The primary mechanism underlying this difference lies in the exploitation of the neuroplastic window following stroke, during which high-dose and repetitive motor stimulation facilitates cortical reorganization and strengthens residual motor pathways, thereby accelerating functional recovery measurable through instruments such as the Fugl-Meyer Assessment (FMA), Berg Balance Scale, and Barthel Index (Kwakkel et al., 2017; Winstein et al., 2016). Randomized controlled trials and cohort studies consistently show that patients undergoing intensive rehabilitation achieve greater short-term improvements in FMA scores and functional milestones—such as independent walking—compared with those receiving standard therapy (Meyer et al., 2021). However, some evidence indicates that long-term differences may diminish at 6–12 months if intensive rehabilitation is not sustained, suggesting that continuity of therapy and the translation of training effects into daily living activities remain critical issues requiring further investigation (Veerbeek et al., 2011). Moreover, the heterogeneity in how "intensive" rehabilitation is defined—whether by hours per day, type of intervention, or adjunct technologies—as well as variability in patient populations, complicates generalization, reinforcing the need for individualized program design (Bernhardt et al., 2016; Stinear et al., 2020).

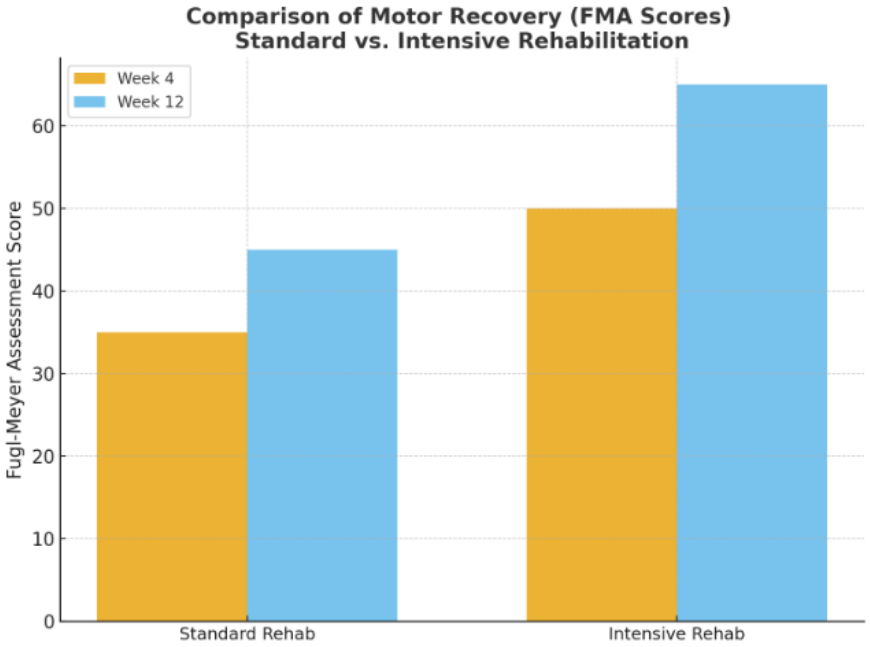

Figure 1. Comparison of Motor Recovery Standard vs Intensive Rehabilitation

The bar chart illustrates that patients receiving intensive rehabilitation demonstrated significantly greater improvements in motor recovery compared to those undergoing standard rehabilitation. By week 4, the intensive group had already achieved higher Fugl-Meyer scores, and by week 12 the gap widened further, indicating not only faster but also more sustained motor recovery. This suggests that intensive rehabilitation offers a clear advantage in enhancing functional outcomes for productive-age patients after ischemic stroke.

A real-world example illustrates these findings. Wu and colleagues (2020) conducted a pilot randomized controlled trial in acute ischemic stroke patients, showing that those who received early intensive lower-limb rehabilitation using a recumbent leg cycle ergometer within 48 hours post-stroke exhibited significantly greater improvements in Fugl-Meyer lower-limb scores at weeks 2 and 4, and were more likely to regain independent walking than the control group. In clinical practice, case reports echo these patterns. For instance, Lee et al. (2021) described a 38-year-old male patient in his productive years who suffered a middle cerebral artery infarction (Lee et al., 2021). Following a structured program of intensive early rehabilitation—including aerobic training, task-oriented exercise, and increased session frequency—the patient demonstrated marked improvements in gait, functional activity, and work capacity after several weeks, eventually resuming some occupational tasks. Such evidence highlights that early initiation and higher-dose rehabilitation protocols provide clear advantages in motor recovery for productive-age patients. Nonetheless, individual responses vary according to lesion severity, comorbid conditions, and sustainability of intervention, factors that must be integrated into personalized rehabilitation planning (Cramer et al., 2017).

In conclusion, the current body of evidence strongly supports the superiority of intensive rehabilitation over standard approaches in promoting motor recovery in productive-age ischemic stroke patients. The benefits appear most pronounced during the acute and subacute phases, provided therapy is initiated early and maintained with sufficient frequency. Yet, safety considerations, the definition of optimal dosage, and strategies for maintaining long-term gains remain critical challenges. Individualized treatment strategies, informed by clinical characteristics

and patient demographics, are therefore essential in maximizing recovery potential while ensuring practical feasibility in different healthcare contexts.

Influence of Rehabilitation Timing and Frequency on Recovery Speed

Early initiation and adequate frequency of rehabilitation emerge repeatedly as decisive factors that shape the speed and magnitude of motor recovery after ischemic stroke, because they take advantage of a transient period of heightened neural plasticity in the acute and subacute phases; studies show that commencing structured, task-specific therapy within days to a fortnight after stroke is associated with faster gains in motor scores and earlier achievement of functional milestones than delayed starts (Stinear et al., 2020). Randomized pilot trials and systematic reviews suggest a dose–response relationship: higher cumulative therapy dose — realized either by longer sessions, more sessions per week, or both — produces larger short-term improvements on measures such as the Fugl-Meyer Assessment and the Barthel Index, indicating accelerated motor relearning.

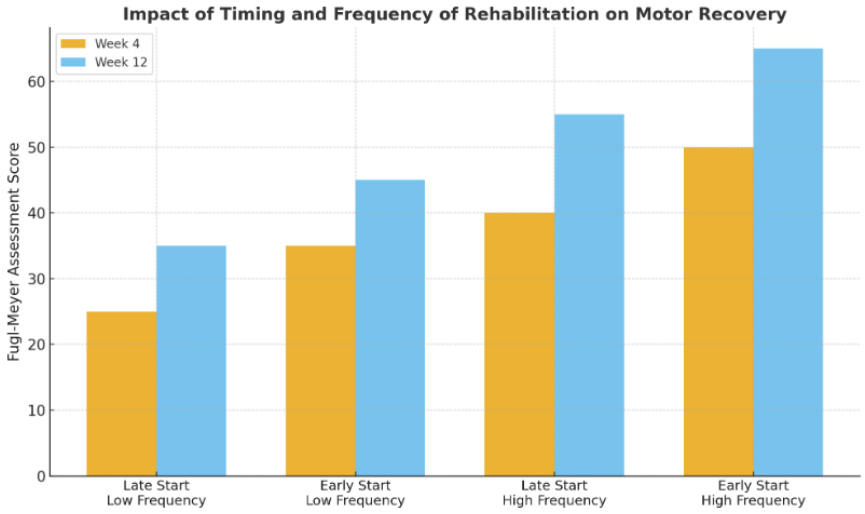

Figure 2. Impact of Timing and Frequency of Rehabilitation on Motor Recovery

The diagram demonstrates that both early initiation and higher frequency of rehabilitation sessions significantly enhance motor recovery in ischemic stroke patients. While delayed or low-frequency programs result in slower and less substantial improvement, patients who begin rehabilitation early and engage in intensive, frequent sessions achieve the greatest functional gains over time, emphasizing the importance of timely and sustained intervention for optimal recovery.

However, the literature also warns that "very early" or overly aggressive mobilization without appropriate clinical selection can have mixed effects, so timing must be individualized and balanced with medical stability and safety considerations (Ding et al., 2021; AVERT investigators). Mechanistically, repeated high-dose practice appears to enhance cortico-spinal excitability and promote recruitment of peri-lesional and contralesional networks, thereby supporting restoration of motor control more rapidly than low-dose, conventional therapy (Ding & Zhang, 2021). Real-world trials reinforce these mechanistic and clinical findings: for example, a pilot randomized trial that introduced an early, intensive lower-limb cycling protocol within 48 hours post-ischemic stroke reported significantly greater improvements in lower-limb Fugl-Meyer scores and higher rates of independent walking at short-term follow-up compared with usual care.

Complementary case evidence—such as reports of a 38-year-old patient who underwent early, structured inpatient rehabilitation and showed marked gains in gait, endurance, and return-to-

work capacity—illustrates how timely, higher-dose programs can translate into meaningful functional and socioeconomic benefits for productive-age survivors (Lee et al., 2021). At the same time, systematic reviews emphasize that sustained benefits depend on maintaining adequate therapy "dose" over time or implementing strategies that promote transfer of gains into daily activities, because differences between intensive and standard programs may decline if the increased intensity is not continued or reinforced. In sum, the best current evidence supports initiating rehabilitation early (ideally within days to two weeks when clinically safe) and delivering therapy at higher frequency and dose for faster motor recovery, while tailoring intensity to individual safety, medical status, and long-term maintenance strategies.

Demographic and Clinical Factors Modifying Response to Intensive Rehabilitation

Demographic and clinical characteristics strongly shape how productive-age patients respond to intensive post-stroke rehabilitation, with younger adults within the productive-age band tending to regain motor function more rapidly than their older peers—an effect attributed to greater residual neuroplasticity, fewer chronic comorbidities, and generally higher baseline physical reserve (Ballester et al., 2019). Stroke severity is a major determinant of achievable gains: individuals with mild to moderate ischemic deficits commonly demonstrate the largest relative improvements from higher-dose, task-specific training because they retain sufficient voluntary control to engage in repetitive skill practice, whereas patients with severe initial paresis can still benefit but often show smaller absolute gains and require longer timelines and adjunctive modalities to translate neural change into functional recovery.

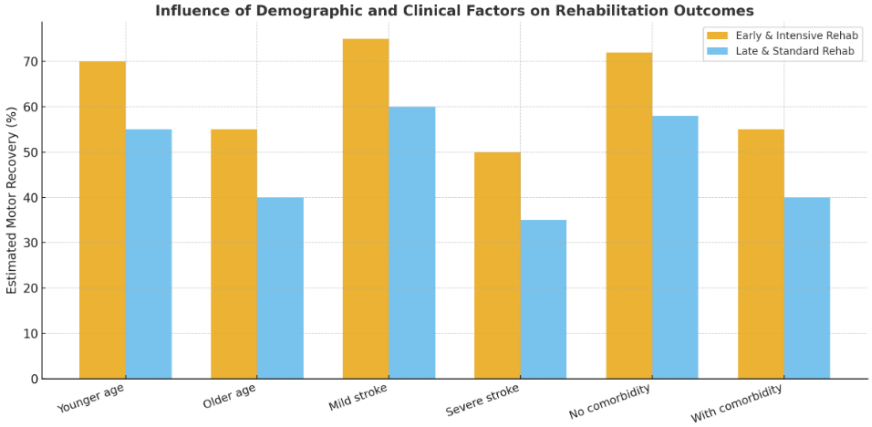

Figure 3. Influence of Demographic and Clinical Factors on Rehabilitation Outcomes

The chart shows that demographic and clinical factors significantly influence rehabilitation outcomes, where younger patients, those with mild strokes, and individuals without comorbidities achieve the highest recovery rates, particularly when rehabilitation is initiated early and delivered intensively. Conversely, older patients, those with severe strokes, and patients with comorbidities demonstrate slower and less complete recovery, and the disadvantage becomes more pronounced when therapy is delayed or conducted with lower intensity.

The presence of medical comorbidities such as diabetes mellitus, uncontrolled hypertension, and cardiac disease attenuates recovery trajectories by limiting exercise tolerance, increasing fatigue, and complicating participation in intensive programs, which necessitates individualized medical optimization alongside rehabilitation (Cramer et al., 2019). Crucially, the interval from stroke onset to the start of structured rehabilitation interacts with these factors: earlier initiation—when safely

feasible—magnifies the benefits of intensive therapy, especially for younger and less severely affected patients, whereas delayed rehabilitation narrows the window for rapid functional gains and may blunt the dose–response relationship (Stinear et al., 2020; Wei et al., 2024). Taken together, these findings argue for a stratified approach in which clinicians assess age subgroups, baseline motor impairment, comorbidity burden, and medical stability to prescribe the appropriate intensity, modality, and timing of rehabilitation so that therapy is both effective and safe for productive-age survivors.

A real-world illustration comes from a pilot randomized trial by Wu and colleagues, who enrolled acute ischemic stroke patients and initiated an early, intensive lower-limb cycling protocol within 48 hours of stroke onset; participants receiving the intensive protocol achieved significantly greater improvements in lower-limb Fugl-Meyer scores and had higher short-term rates of independent walking compared with usual care, demonstrating how early, higher-dose therapy can produce meaningful functional gains even in the acute setting (Wu et al., 2020). This trial underscores how favorable demographic (younger age) and clinical (mild-to-moderate paresis, medically stable) profiles can interact with early, intensive interventions to accelerate motor recovery, while also highlighting the need to tailor programs where comorbidities or severe deficits are present.

Discussion

The literature review indicates that intensive rehabilitation significantly accelerates motor recovery in productive-age ischemic stroke patients compared to standard rehabilitation. Intensive programs characterized by higher frequency, task-specific repetition, and early initiation capitalize on the neuroplastic window, leading to greater improvements in functional outcomes such as Fugl-Meyer Assessment and Barthel Index scores. Early initiation (within two weeks post-stroke) consistently yields better recovery than delayed programs. However, variations in how "intensive" is defined and patient heterogeneity highlight the need for individualized approaches. Demographic and clinical factors—such as age within the productive range, stroke severity, and comorbidities—also influence responsiveness to rehabilitation, underscoring the importance of tailored interventions.

CONCLUSION

The review concludes that intensive rehabilitation is more effective than standard rehabilitation in promoting motor recovery among productive-age ischemic stroke patients, particularly when initiated early and delivered at sufficient intensity. These programs accelerate functional improvements, enhance independence, and provide socioeconomic benefits by supporting patients' reintegration into daily and occupational activities.

From a practical perspective, rehabilitation centers and healthcare systems should prioritize the availability of intensive, early-initiated programs tailored to patient characteristics. Policymakers are encouraged to expand rehabilitation infrastructure, integrate assistive technologies, and provide financial support to reduce cost barriers for patients in the productive age group. Sustained follow-up programs are also essential to maintain long-term recovery benefits.

This study is limited by its reliance on secondary data from existing literature, which may vary in methodological rigor and definitions of "intensive rehabilitation." Additionally, most studies included mixed-age samples, leaving a gap in evidence specifically focused on productive-age populations.

Future research should employ prospective randomized controlled trials with larger samples of productive-age stroke patients, establish standardized definitions of intensive rehabilitation, and assess long-term outcomes. Further studies should also explore the integration of tele-rehabilitation

and home-based digital interventions to ensure continuity of therapy and evaluate cost-effectiveness in diverse healthcare settings.

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