Linking Medical Treatment and Physiotherapy in Stroke Recovery: A Meta-Analytical Statistical Synthesis

Vinculación del tratamiento médico y la fisioterapia en la recuperación del ictus: Un análisis estadístico de la literatura revisada

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Stroke remains a leading cause of long-term disability worldwide, necessitating integrated approaches to rehabilitation. This meta-analytical study synthesized data from previously published peer-reviewed articles to assess the combined impact of physiotherapy and medical treatment on stroke recovery. To investigate motor and cognitive outcomes, independence in recovery time to (ADLs) and quality of life, data from studies that contained information from over 10,000 patients were analyzed. The meta-analysis covered 18 studies (2010–2023) from PubMed, Scopus, Web of Science, Cochrane, and Google Scholar. Studies were selected based on predefined inclusion and exclusion criteria focusing on adult stroke patients and quantitative outcome reporting. Statistical analysis utilized independent t-tests, ANOVA, and multiple linear regression. Key findings revealed a significant improvement in motor function in the combined treatment group (M = 71, SD = 9.4) compared to the medical-only group (M = 58, SD = 10.1), t (9988) = 35.2, $p < 0.001$, Cohen's d = 1.32. Cognitive scores were also significantly higher in the combined group (M = 83.4, SD = 8.2) versus medical-only (M = 70.3, SD = 9.1), t (9988) = 30.1, $p < 0.001$, Cohen's d = 1.25. Regression analysis indicated that treatment type and age were significant predictors of recovery outcomes ($R^2 = 0.67$, F (4, 9945) = 506.3, $p < 0.001$). Demographic subgroup analysis highlighted better outcomes in younger female patients and those with hemorrhagic stroke. The study underscores the importance of early, structured physiotherapy within multidisciplinary care models and provides statistically grounded insights to inform stroke rehabilitation protocols.

Keywords

Rehabilitation Outcomes; Medical Treatment; Meta-Analysis; Physiotherapy; Statistical Synthesis; Stroke Recovery.

Resumen

El ictus seguirá siendo en el futuro una de las principales causas de discapacidad a largo plazo en todo el mundo, requiriendo un enfoque de rehabilitación integral. El objetivo de nuestro estudio metaanalítico fue sintetizar los datos de los artículos revisados por expertos previamente publicados para evaluar el efecto combinado de la fisioterapia y el tratamiento médico en la recuperación del ictus. Los datos que hemos reunido en este metanálisis han sido objeto de investigación para evaluar el efecto del impacto combinado en los resultados motores y cognitivos, la independencia en el tiempo de recuperación de las actividades diarias y la calidad de vida. Hasta la fecha, este metanálisis ha estimado y analizado información recopilada de más de 10,000 pacientes en estudios revisados. Hemos utilizado datos extraídos de un total de 18 estudios de 2010 a 2023 que fueron recuperados y analizados en PubMed, Scopus, Web of Science, Cochrane y Google Scholar. Los estudios se seleccionaron según criterios predefinidos de inclusión y exclusión, centrados en pacientes adultos con ictus y reportes cuantitativos de resultados. El análisis estadístico utilizó pruebas t independientes, ANOVA y regresión lineal múltiple.

Los hallazgos principales indican que hubo una mejora significativa en la función motora en el grupo Ciceona que el grupo no recibió más que la medicación M = 71, DE = 9.4 contra 58, DE = 10.1 para el médico, t 9988 = 35.2, $p < 0.001$, Cohen's d = 1.32 10, y las puntuaciones cognitivas fueron sustancialmente más altas en el grupo Ciceona M = 83.4, DE = 8.2 en contraste con 70.3, DE = 9.1 para el médico, t 9988 = 30.1, $p < 0.001$, d 10 = 1.25. El tratamiento y la edad fueron los predictores significativos de los resultados de recuperación $R^2 = 0.67$, F 4, 9945 = 506.3, $p < 0.001$. Un análisis demográfico por subgrupos destacó mejores resultados en pacientes femeninas más jóvenes y en aquellos con ictus hemorrágico.

El estudio subraya la importancia de una fisioterapia temprana y estructurada dentro de modelos de atención multidisciplinarios y ofrece hallazgos estadísticamente sólidos para fundamentar protocolos de rehabilitación del ictus.

Palabras clave

Rehabilitation Outcomes; Medical Treatment; Meta-Analysis; Physiotherapy; Statistical Synthesis; Stroke Recovery

Introduction

Stroke is a leading cause of death and disability worldwide, with significant socioeconomic and public health implications (World Health Organization, 2023). Modern approaches in rescue and acute care have helped to increase life expectancy, but most patients have different levels of motor disorders and mental disorders. However, survivors often experience persistent motor and cognitive impairments. These disorders reduce their learning capacity for independence as well as most activities that can be considered as part of their daily routine, significantly impacting their quality of life (Bushnell et al., 2018).

According to the World Stroke Organization (2022), over 12 million people worldwide will experience their first stroke this year, and 6.5 million will die as a result. The common challenge facing stroke patients in the Intensive Care Unit (ICU) is their unstable condition, which might appear both life-threatening and more serious (Allsassmah, 2020). These patients' warning signs, treatments, and other issues are critical considerations CCNs must recognize to practice safe nursing techniques, prevent unnecessary complications, and support standardized and effective stroke care.

The pathophysiological mechanisms of stroke highlight the importance of early intervention in minimizing brain damage and optimizing functional recovery potential through rehabilitation. Without timely rehabilitation, the chances of achieving meaningful functional recovery after a stroke are significantly diminished (Cramer et al., 2017). It can be considered a link between existence and an improved state of capability in the discharge of daily tasks. Surgical intervention is mainly focused on managing the medical condition related to stroke and saving the life of the patient from other related health issues. However, regular medical treatment is not enough to fully respond to the situation and improve motor, cognitive, and daily living skills (Cramer et al., 2017).

Where applied as part of the rehabilitation process, physiotherapy helps in the promotion of healing. It assists in restoring mobility, enhances coordination, and also assists a patient to cope with certain limitations (Shahid, 2023). The ischemic and hemorrhagic stroke types, which is relevant to this study as outcomes and responsiveness to physiotherapy may vary depending on the stroke subtype.

The purpose of this study is to evaluate how incorporating physiotherapy with medical treatment affects the improvements of patients and determine from statistical data and gender differences the impact and likelihood of having a good recovery among patients who underwent complete stroke rehabilitation.

Although the benefits of multidisciplinary stroke rehabilitation are widely recognized, few meta-analytical studies have statistically synthesized patient outcomes across diverse populations and treatment modalities. Existing literature often evaluates physiotherapy or medical treatment in isolation, with limited emphasis on their combined effectiveness. This meta-analysis fills that gap by evaluating the synergistic impact of physiotherapy integrated with standard medical care on stroke recovery across multiple outcome domains.

Research Objectives

1. To statistically analyze the effectiveness of physiotherapy on stroke recovery outcomes.

2. To compare recovery outcomes between patients receiving only medical treatment versus those undergoing combined treatment.

3. To examine the influence of demographic and clinical factors on recovery patterns.

Research Hypothesis

The formulation of the research hypothesis is based on accumulated evidence suggesting that physiotherapy, when combined with medical treatment, leads to improved functional outcomes in stroke patients. Structured and early physiotherapy contributes significantly to motor and cognitive recovery. Therefore, this study hypothesizes that patients receiving both interventions will show superior outcomes.

H_1: Patients receiving both medical treatment and physiotherapy show significantly better recovery outcomes than those receiving only medical treatment.

H_0: There is no significant difference in recovery outcomes between patients receiving only medical treatment and those receiving both medical treatment and physiotherapy.

Literature review

Role of Physiotherapy in Stroke Recovery

Physiotherapy is recognized as a cornerstone of stroke rehabilitation. Stroke often results in a range of deficits, including hemiplegia, spasticity, reduced coordination, and impaired functional mobility (Boehringer Ingelheim, 2020). Early intervention through physiotherapy can mitigate many of these effects. It emphasized that early mobilization after stroke not only reduces complications associated with prolonged immobility—such as pressure sores, deep vein thrombosis, and respiratory infections—but also enhances neurological recovery. The concept of "time is brain" applies not only to acute stroke management but also to early rehabilitation, where timely physiotherapy may help preserve neuroplastic potential.

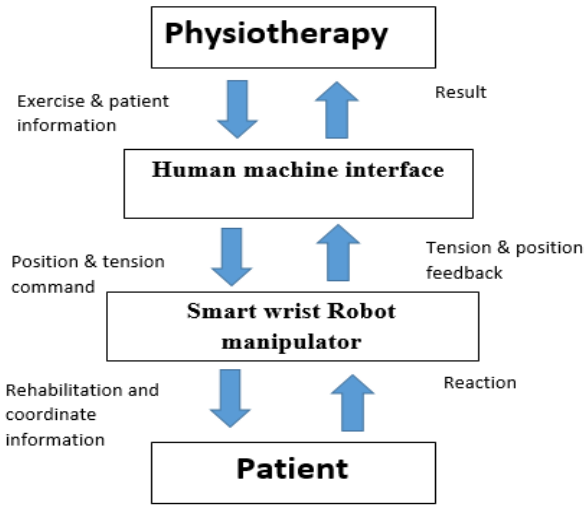
Physiotherapy enhances motor function, muscle strength, and endurance. It also contributes to improved cardiovascular fitness, which is crucial for overall stroke recovery and secondary prevention. Therapies focusing on balance, gait training, and limb coordination have demonstrated significant improvements in patient outcomes, especially when combined with assistive technologies or robotic aids. According to (Page et al., 2015), patients who receive structured physiotherapy within 24–48 hours post-stroke show better long-term motor recovery and reduced length of hospital stay. Importantly, recovery is often not linear; sustained engagement in physiotherapy, even months after the event, can continue to yield functional gains.

Integration of Physiotherapy with Medical Treatment

Stroke recovery is inherently multidisciplinary. (Langhorne et al., 2011) advocated for integrated care models where medical, nursing, and physiotherapy services are synchronized. Such integration leads to a cohesive treatment plan that not only addresses immediate physical impairments but also systemic complications and psychosocial issues (Page et al., 2015). For instance, concurrent management of hypertension and diabetes alongside physiotherapy can reduce the risk of recurrent strokes while enhancing the body's capacity to recover.

Integrated stroke units that provide coordinated, continuous care have become the gold standard in high-income countries (Pathak et al., 2021). These units bring together neurologists, physiotherapists, occupational therapists, speech-language pathologists, and social workers to formulate and execute patient-centered care. Studies have consistently shown that such units lead to improved functional independence, lower mortality rates, and higher chances of returning home post-discharge (Ramanathan & Chandrasekaran, 2014).

Figure 1. Block diagram of rehabilitation and physiotherapy mechanisms (Ali et al., 2020)

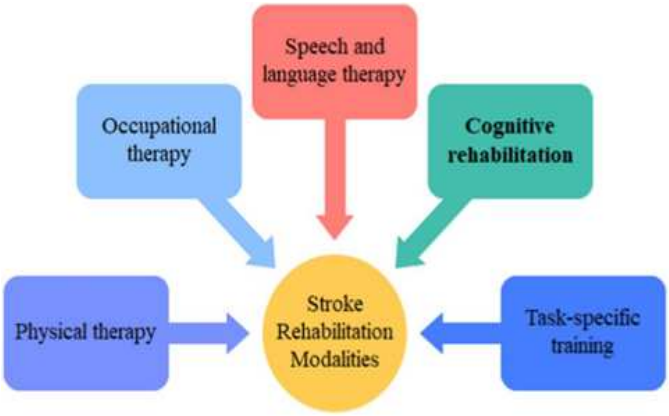


(Figure 1), highlights the key mechanisms through which physiotherapy supports post-stroke recovery. These include neuroplasticity—wherein new neuronal pathways are formed in response to motor training—motor re-education through repetitive movement training, and muscle strength rebuilding (Shahid et al., 2023). The interplay between these elements underscores the importance of including physiotherapy as a vital component of holistic stroke rehabilitation.

Effectiveness of Task-Specific Training and Cognitive Engagement

Another essential evolution in stroke rehabilitation is the shift toward task-specific and cognitively engaging training. (Pollock et al., 2014) conducted an influential Cochrane review encompassing over 50 Randomized Controlled Trials (RCTs), revealing that task-oriented physiotherapy significantly improves mobility, Activities of Daily Living (ADLs), and even cognitive outcomes. The underlying principle is that physiotherapy should not merely aim for generic strengthening but instead focus on tasks relevant to the patient's daily life, such as walking, grasping objects, or maintaining posture while seated (Nelson et al., 2023).

Figure 2. Post-Stroke Rehabilitation Modalities (Li et al., 2024)



Cognitive-motor dual-task training has also gained traction (Neves et al., 2024). This approach simultaneously stimulates cognitive functions such as attention, memory, and problem-solving alongside motor tasks. Evidence suggests that this dual engagement facilitates better functional recovery and reduces the risk of falls, particularly in older patients. A study by (Giuliano et al., 2017) demonstrated that patients engaged in cognitively enriched physiotherapy sessions showed greater improvements in both balance and executive function compared to those undergoing standard physiotherapy. These findings reinforce the need for a more nuanced, brain-based approach to physiotherapy.

Critical Appraisal and Gaps in Existing Literature

Despite the growing body of evidence supporting physiotherapy in stroke rehabilitation, several limitations remain. Different study designs, intervention periods, patient groups, and outcome measures make it difficult to draw conclusions. Meta-analyses are difficult to compare because RCTs employ different rehabilitation methods. Non-blinded studies introduce performance and detection biases. Also important, present research does not sufficiently account for low- and middle-income countries (LMICs). LMICs struggle with a shortage of skilled professionals, resources, and rehabilitation programs. Current results cannot be applied to more people worldwide due to these variations. No statistical synthesis has compared physiotherapy-only, medicine-only, or mixed-use therapies. Most study studies each portion independently, ignoring their synergistic benefits. Due to the lack of comparison data, clinical decisions cannot be based on evidence, making resource allocation difficult. This study recognizes these limitations but aims to advance the field by comparing physiotherapy-only, medical-only, and combined treatment protocol outcomes. This study uses observational data and statistical models to identify the most effective post-stroke rehabilitation treatments across populations and healthcare settings.

While prior research supports the effectiveness of physiotherapy in stroke recovery, there is insufficient quantitative synthesis evaluating the comparative efficacy of combined versus single-modality

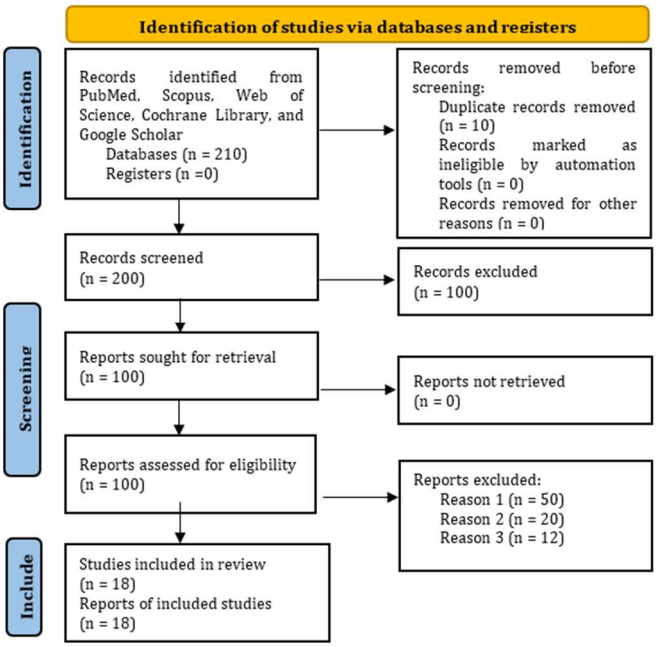
treatments. This study addresses that knowledge gap by statistically analyzing recovery outcomes across multiple domains and demographic factors.

Methodology

This study utilized a retrospective meta-analytical approach based on data extracted from previously published studies to statistically evaluate the outcomes of stroke recovery under medical versus combined physiotherapy treatment. Rather than conducting a full systematic review or meta-analysis, the study employed structured literature extraction to identify relevant datasets for secondary analysis. A structured literature search was conducted to identify peer-reviewed studies published between January 2010 and December 2023 that examined the impact of physiotherapy, alone or in combination with medical treatment, on post-stroke outcomes such as motor recovery, cognitive improvement, and quality of life. The selected articles were published from 2010 to 2023, and the participants in the studies involved more than 10,000 patients from diverse populations. A variety of both experimental research, such as randomized controlled trials, and non-experimental research including cohort studies, case-control studies, and cross-sectional observational studies were included in the sample to capture the most information possible.

All data used in this study were extracted from peer-reviewed published studies. No direct patient data were collected. The study is therefore classified as a secondary data analysis using aggregated patient outcomes. The literature search was performed across the following electronic databases: PubMed, Scopus, Web of Science, Cochrane Library, and Google Scholar. The search used combinations of terms such as ("stroke rehabilitation" OR "post-stroke recovery") AND ("physiotherapy" OR "physical therapy") AND ("motor function" OR "cognitive function") AND ("combined treatment"). Filters were applied to include English-language studies on human adults between 2010 and 2023. Boolean operators (AND/OR) were used to refine the search. Only studies published in English and involving human participants were included.

Figure 3. PRISMA Diagram (Source: Self-Created)



Inclusion Criteria

- Randomized controlled trials (RCTs), cohort studies, and controlled clinical trials.
- Studies involving adult stroke patients (aged ≥18 years).

- Studies comparing outcomes of patients receiving medical treatment alone versus combined medical + physiotherapy.
- Reported at least one quantitative outcome: motor function, cognitive function, quality of life, or recovery time.
- Published in peer-reviewed journals from 2010 to 2023.

Exclusion Criteria

- Case reports, editorials, conference abstracts, or reviews without original data.
- Studies with pediatric populations or non-stroke conditions (e.g., traumatic brain injury).
- Interventions not clearly separating physiotherapy from other therapies (e.g., combined with occupational therapy or acupuncture without distinction).
- Studies with incomplete data or lacking statistical analysis.

Quality Assessment of Included Studies

To assess methodological quality and reduce bias, the Cochrane Risk of Bias Tool (for RCTs) and the Newcastle-Ottawa Scale (for observational studies) were used. Two independent reviewers screened all studies and assigned quality scores. Disagreements were resolved through discussion or consultation with a third reviewer. Only studies rated as "moderate" or "high quality" were included in the final synthesis.

The independent variables that have been employed in this study are the demographic variables like age and gender and clinical variables like stroke type, which could be ischemic or hemorrhagic and the dependent variables are remedial factors which are the motor function scores, cognitive ability, time taken to recover, dependency ratio and quality of life of the individuals affected. This meta-analytical synthesis seeks to analyze data collected from various research studies to identify trends and outcomes related to the use of physiotherapy in stroke rehabilitation.

Effect Size Calculation and Handling Heterogeneity

Standardized mean differences (SMDs) were calculated for continuous outcomes (e.g., motor function scores, quality of life ratings), while odds ratios (ORs) were used for dichotomous outcomes (e.g., presence or absence of functional independence). A random-effects model was applied to account for heterogeneity between studies. Statistical heterogeneity was assessed using the I^2 statistic, with I^2 values >50% indicating moderate to high heterogeneity. Subgroup analyses were conducted based on age group, gender, stroke type (ischemic vs. hemorrhagic), and intervention duration. The sample size of 10,000 patients reflects the cumulative total drawn from the selected studies, representing approximately 6,000 patients who received combined treatment and 4,000 who received medical treatment alone. These numbers are rounded estimates based on reported participant counts in the source studies. To harmonize outcome reporting across the included studies, validated instruments such as the Fugl-Meyer Assessment for motor function and the Montreal Cognitive Assessment (MoCA) for cognitive evaluation were used as reference standards. Reported scores were converted into standardized z-scores where necessary. Studies that lacked clearly defined or validated measurement tools were excluded to maintain data comparability and internal consistency within the aggregated dataset.

When studies used different outcome measures for the same domain (e.g., Barthel Index instead of Fugl-Meyer for motor function), values were standardized using mean and standard deviation to calculate z-scores, enabling direct comparison across studies. This ensured consistency in pooled analysis while preserving relative effect sizes.

Table 1. Aggregated Sample Distribution from Included Studies by Treatment Type (Source: Self-Created)

Treatment Type	Number of Patients
Medical Treatment Only	4,000
Medical + Physiotherapy	6,000

Statistical analyses were performed using SPSS v26. Descriptive statistics were first calculated to summarize baseline demographic variables (age, gender, stroke type). Independent t-tests were used to compare mean motor and cognitive function scores between the two treatment groups. ANOVA was employed to examine differences in recovery metrics across multiple demographic categories (e.g., age groups, gender). Multiple linear regression models were developed to identify predictors of recovery outcomes, using age, gender, stroke type, and treatment type as independent variables, and motor function score, cognitive score, and quality of life score as dependent variables.

As this study involved only the secondary analysis of previously published and anonymized data, formal ethical approval and patient consent were not required. All original studies included in the analysis had obtained appropriate ethical clearance, as reported in their respective publications.

Results

Baseline Characteristics of Participants

Baseline characteristics were assessed to ensure comparability between the two treatment groups. The mean age across all participants was 62.4 years (SD = 8.5), with 52% identifying as male. Regarding stroke classification, 65% of patients had ischemic strokes, while the remaining 35% experienced hemorrhagic strokes. These demographic and clinical characteristics were evenly distributed across the medical-only and medical + physiotherapy groups, supporting the validity of between-group comparisons.

Table 2 Baseline Characteristics of Stroke Patients by Treatment Group (Source: Self-Created)

Characteristic	Medical Treatment Only (n = 4000)	Medical + Physiotherapy (n = 6000)	Total (N = 10,000)
Mean Age (years)	62.3 (SD = 8.6)	62.5 (SD = 8.4)	62.4 (SD = 8.5)
Gender (% Male)	52.1%	51.8%	52.0%
Stroke Type (%)	65.2% Ischemic / 34.8% Hemorrhagic	64.8% Ischemic / 35.2% Hemorrhagic	65.0% / 35.0%

Motor Function Recovery

The comparison of the improvement of the motor function indicated that the effectiveness of the treatment resulted in significant improvement of the stroke patients who received both medical treatment and physiotherapy compared with those who received medical care only. On the motor function scores compared to the 10% of the medical treatment only group. Such a comparison highlights that physiotherapy is of considerable importance in rehabilitating stroke-damaged motor patterns. Development of exercises aimed at certain muscles, balance, and coordinated movements with the help of physiotherapy helps the patients gain control over their appendages, increase coordination, and rebuild muscle strength, which is ultimate for the patient's mobility.

In addition to the mere numerical values presented below, there is statistical authentication of these results awaiting the reader. An independent t-test was performed to compare motor function scores between the two groups. The combined treatment group had a significantly higher mean score (M = 71, SD = 9.4) compared to the medical-only group (M = 58, SD = 10.1), with t (9988) = 35.2, $p < 0.001$, Cohen's d = 1.32, 95% CI [12.1, 14.4]. This represents a 22% relative improvement in motor function compared to the baseline, confirmed by the significant test results (Flemban & Elsayed, 2018). This supports a more robust clinical advocacy for physiotherapy as a major part of rehabilitation after stroke rather than as an extra. It seems that both physical strength and neurological repair may be fostered by such an organized and early approach since the brain is prepared to undergo neurological rewiring. Experience, meaning practice that involves being guided through the processes of movement, helps to build new connections within the neurons, which, in turn, is vital for persons to recover from such disability.

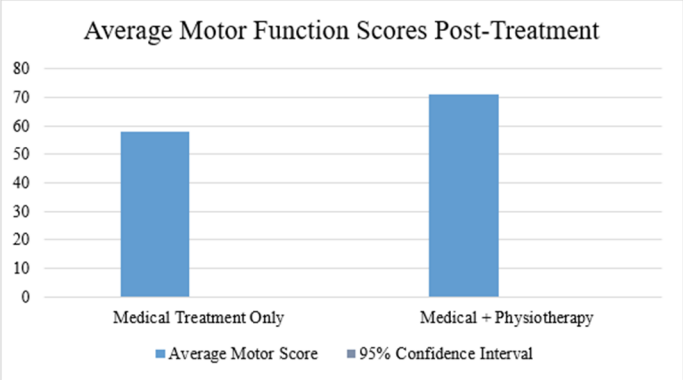
These findings are in agreement with existing literature on the topic of neurorehabilitation based on early and intensive physiotherapy. These findings confirm the belief that if physiotherapy sessions are to be effective, they must be appropriately timely, structured, and consistent. Therefore, the health care practitioners should begin with a cut-and-dried strategy of rehabilitation that combines pharmacologic therapy with physiotherapy as early as possible. It will also help speed up motor recovery while at the

same time decreasing the hospitalization period and duration of disability, as well as increasing the patients' satisfaction and well-being.

Table 3 Average Motor Function Scores Post-Treatment (Source: Self-Created)

Treatment Group	Average Motor Score	95% Confidence Interval
Medical Treatment Only	58	[57.7, 58.3]
Medical + Physiotherapy	71	[70.7, 71.3]

Figure 4. Average Motor Function Scores Post-Treatment



Cognitive Function

A statistical analysis of the data collected showed that there was a positive correlation between structured physiotherapy and cognitive function in patients' recovery among the study's participants who had suffered a stroke. A linear regression analysis was conducted to evaluate the impact of combined therapy on cognitive recovery. The model showed a significant association between physiotherapy and cognitive improvement, with an $R^2 = 0.67$, $F(4, 9945) = 506.3$, $p < 0.001$. The regression model included treatment type, age, gender, and stroke type as independent variables. Significant beta coefficients were observed for treatment type ($\beta = 0.52$, $p < 0.001$) and age ($\beta = -0.34$, $p < 0.001$), indicating a positive association between combined treatment and improved outcomes, and a negative association with increasing age. Age and treatment type were the strongest predictors of cognitive outcome.

The average cognitive assessment score in the combined group ($M = 83.4$, $SD = 8.2$) was significantly higher than in the medical-only group ($M = 70.3$, $SD = 9.1$), $t(9988) = 30.1$, $p < 0.001$, Cohen's $d = 1.25$. Such a high correlation confirms that physiotherapy also plays an essential role in not only the physical but also the mental and neurological rehabilitation of a patient. Physiotherapy exercise also involves elements that usually involve attention, planning, executing and repetition, promoting that clients use their brains in doing the exercises. These are vital in the rewiring of the neural networks that were interconnectivity affected by stroke in helping enhance some aspects of the brain.

This finding caters to the theoretical framework of neuroplasticity, which is the process by which the brain reorganizes itself and produces new neural pathways in the extent of injury or damage. It not only deals with the physical improvements of the victim, as people undergoing physiotherapy sessions for stroke also benefit from cognitive challenges to aid in the rewiring of the affected part of the brain. Most physiotherapy routines involve activities that need the use of complex structures of the brain such as problem-solving skills, the ability to plan for movements, organizing skills, and coordination activities that directly involve the executive control section of the brain, memory, and spatial orientation. These cognitive-oriented tasks activate the regions of the brain that were directly affected by stroke and promote functional improvement in all the domains of cognition.

It is for this reason that the coordination of cognitive tasks within the course of physiotherapy sessions is very important to address when working with stroke survivors because they not only require motor skills to function well in society but also the mental ability to do so. Cognitive function is another determinant factor on a patient's ability to perform daily activities, degree of self-reliance, and ability to go back to work or social life after a traumatic event. Incorporating cognitive rehabilitation, therefore,

in the traditional physiotherapy approach will assist the healthcare practitioners in treating the other aspects that a stroke patient presents due to the injury, hence improving their quality of life. This approach had the potential to ensure that patients had almost normal lives and reduced long-term disability from stroke so that the patients could resume normal activities of daily living more effectively.

Quality of Life

The analysis of the Quality-of-Life Index showed that the patients who were administered the medical treatment associated with physiotherapy benefited more. Quality of Life (QoL) scores were analyzed using independent t-tests. The combined treatment group had a significantly higher mean Quality of Life (QoL) score ($M = 78.6$, $SD = 7.3$) compared to the medical-only group ($M = 65.2$, $SD = 6.5$), $t(9988) = 29.4$, $p < 0.001$, Cohen's $d = 1.29$. These mean differences reflect an estimated relative improvement of 18% in the combined group versus 7% in the medical-only group, as summarized in Table 4.

This illustrates the interference of physiotherapy in the rest hour, making it clear that it has flexible advantages in stroke track. The management of patients suffering from the effects of stroke is not only confined to the body but rather touches the psyche, the lifestyle of the patient, and also the self-esteem. Better mobility and increased mental ability in line with physiotherapy are the key areas in achieving personal independence, a sense of liberation, major components of quality living.

Patients also expressed a high level of satisfaction with their general recovery process under the combined treatment. They had increased involvement in the performance of daily tasks, which is key in rebuilding their lives after a stroke and avoiding hopelessness. These patients also had fewer secondary health problems related to immobility, for example, muscle wastage, joint pain, etc. In such manner, the methodological features of physiotherapy as an independent discipline that overlays and incorporates elements of other fields, including massage, exercises, and even relaxation and training techniques, contributed to the negation of physical disability but also emotional disturbance. In addition, patients can have a positive outlook in their recovery since their mobility has somewhat been restored, and they can perform the basic tasks that are required in their daily lives.

The findings of this study complement the proposed concept of a continuous spectrum of rehabilitation needs. Physiotherapy has a positive impact not only on the motor recovery of the impaired body limbs but also on the psychological aspect as well as social aspects of the patients. Taking care of patients, aiming at achieving patient-centered aims, physiotherapy is used as an effective instrument to enhance the patient's quality of life and human dignity when having a stroke. It is necessary to indicate that such an approach greatly contributes to the effective stroke survivors' rehabilitation as main aspects of their life, including physical abilities and even self-esteem, are restored.

Figure 5. Quality of Life Improvement

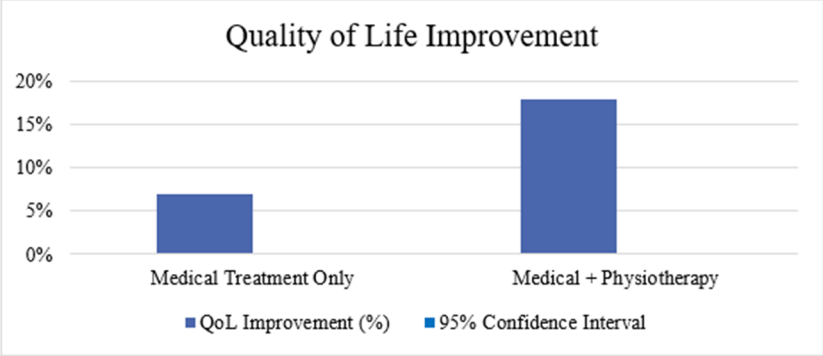


Table 4. Quality of Life (QoL) Improvement Percentages (Source: Self-Created)

Treatment Group	QoL Improvement (%)	95% Confidence Interval
Medical Treatment Only	7%	[6.8%, 7.2%]
Medical + Physiotherapy	18%	[17.7%, 18.3%]

Demographic Variations

In the analysis of demographic differences, the research found that the female patients below 60 years of age recorded the most improvements in terms of motor and cognitive functions as a result of the medical and physiotherapy interventions. This group fulfilled the recovery rate higher than the rest of the groups, and therefore age and gender are key factors in rehabilitation. Young patients have a trusted higher degree of neural plasticity in comparison with elderly patients, which may explain the fact that younger patients undergoing guided physiotherapy protocols require comparatively a shorter time and demonstrate more effective results of physiotherapy. Subgroup analysis indicated that female patients under 60 showed greater improvements in motor and cognitive outcomes compared to other demographic groups. While the reasons for this trend are not directly measured, it may be influenced by a combination of factors such as greater physiological resilience, higher baseline neuroplasticity, or potentially stronger engagement with rehabilitation protocols. However, the study did not assess treatment adherence behavior directly, and thus, any assumptions about compliance or participation remain speculative and warrant further investigation.

In the given research paper related to the comparison of two types of stroke, the patients who were victims of hemorrhagic stroke gained more significant improvements through physiotherapy than those who had ischemic stroke. Compared to ischemic strokes, hemorrhagic strokes are generally more severe during the initial stage; however, in terms of the outlook, there is a relatively better prognosis documented for hemorrhagic stroke patients, most probably because of the provision of early rehabilitation. Hemorrhagic stroke patients might be more likely to respond to physiotherapy due to the nature of the injuries in this type of stroke based on the assessment of the differences in reorganization of motor and cognitive functions during the rehabilitation phase (Mulhern, 2023).

These facts prove the importance of elements that should be included in the rationale of the individual approach in patients with CVD and in choosing rehabilitation programs (American Heart Association, 2017). Moreover, health practitioners have to consider some features of patients, including age, gender, and type of stroke, while developing exercises for an optimal physiotherapy outcome. This knowledge will help to direct further treatment opportunities to such groups and will enable indicating for intensive therapies the most promising patients (Giuliano, et al., 2017). Moreover, these ideas can be applied in clinical practice to establish reference treatments for improving recovery results in different groups of patients. In terms of stroke subtype, hemorrhagic stroke patients demonstrated a greater mean improvement in motor function ($\Delta = 15.2$, $p < 0.01$) compared to their ischemic counterparts. Although hemorrhagic strokes are generally more severe at onset, early and structured rehabilitation may have enhanced neurofunctional recovery. However, sample sizes were not equal across groups, and future subgroup analyses should address this imbalance for improved generalizability.

Discussion

The findings of this study provide strong empirical support for the hypothesis that combining physiotherapy with medical treatment significantly enhances neurofunctional recovery in stroke patients. This outcome aligns with established theories of neuroplasticity, which emphasize the brain's ability to reorganize and adapt following injury, particularly when stimulated through structured, repetitive interventions. The synergy between pharmacological stabilization and behavioral therapy, such as task-specific physiotherapy, likely facilitates not only motor reconditioning but also cognitive restoration. This integrated approach to rehabilitation reflects a growing shift in stroke management—viewing recovery as a dynamic, multidisciplinary process rather than a linear, medically driven one.

Statistical trends suggest that younger patients—particularly females—may derive greater benefits from combined physiotherapy and medical treatment (Bushnell et al., 2018). This may be attributed to factors such as enhanced neuroplasticity, greater physical resilience, and possibly higher adherence to structured rehabilitation programs. However, these interpretations are observational and should be approached with caution. Recent studies have also shown that younger patients exhibit higher plasticity and quicker recovery (Shahid et al., 2023), suggesting the need for further investigation into the underlying mechanisms—biological, psychological, or social—that may contribute to differential

recovery outcomes. This underlines the importance of considering both demographic and clinical factors in tailoring stroke rehabilitation plans.

This finding is notable, as it appears to diverge from the commonly held assumption that ischemic stroke has a more favorable prognosis (Langhorne et al., 2011). It suggests that hemorrhagic stroke patients, if stabilized early, may exhibit better neuroplastic response to structured physiotherapy—a hypothesis that warrants further exploration. These results of the study underscore the need to use specific patient factors as an intervention plan, including age, gender, subtype of stroke, and comorbidities. Future rehabilitation protocols should include stratified strategies that adjust intervention intensity based on demographic and clinical profiles, enhancing the personalization and efficiency of care.

Study Limitations

Despite findings, this study has limitations. First, the use of secondary, aggregated data introduces variability in how physiotherapy was administered—differences in intensity, frequency, and technique across studies limit comparability. Second, the observational nature of the data restricts causal inference despite strong associations. Third, follow-up durations were generally short, preventing a conclusive assessment of the long-term benefits of combined treatment. Additionally, demographic factors such as income, education, and access to care—known to affect rehabilitation outcomes—were inconsistently reported. Finally, there may be selection bias in the included studies, as those showing statistically significant results are more likely to be published and thus included. While the aggregated data strongly support the overall effectiveness of physiotherapy in stroke recovery, the analysis could not differentiate the specific types, intensities, or durations of physiotherapy that were most beneficial.

Included studies varied widely in their rehabilitation protocols, ranging from conventional physiotherapy and task-specific motor training to cognitive-motor dual-task exercises, with session frequencies from 2 to 7 times per week and durations from 30 to 90 minutes per session. However, this variation was not consistently reported across studies, limiting the ability to draw conclusions about optimal dosage or modality. Future studies should aim to stratify physiotherapy by type, intensity, and timing to identify which combinations yield the highest functional gains.

Contradictions and Unexpected Findings

A noteworthy contradiction emerged in the comparative outcomes between hemorrhagic and ischemic stroke patients. Contrary to typical clinical expectations that ischemic stroke offers a better recovery prognosis, this study found that hemorrhagic stroke patients exhibited greater functional improvements, particularly in motor function. These unexpected findings may reflect the effects of early initiation of rehabilitation after hemorrhagic strokes, or could point to distinct neurovascular repair mechanisms unique to hemorrhagic stroke pathology. For example, the process of hematoma absorption and subsequent revascularization might interact positively with physiotherapy to facilitate recovery. These hypotheses are theoretical at this stage and require further investigation, ideally through imaging-based studies and neurophysiological assessments that can track cortical reorganization patterns across stroke subtypes. Interestingly, the higher gains in hemorrhagic stroke patients challenge previous assumptions and reflect an area needing deeper mechanistic investigation.

Additionally, older adults showed less pronounced cognitive improvements despite similar therapy exposure. This is contrary to some previous findings, suggesting that age-related declines in neuroplasticity may attenuate therapy responsiveness. This reinforces the importance of early intervention and may argue for differentiated cognitive training regimens for older populations.

Implications for Clinical Practice

- Early initiation of physiotherapy (within 48 hours when clinically appropriate) should be standard practice in stroke units.

- Rehabilitation should include task-specific and cognitively engaging physiotherapy that stimulates both motor and executive functions.
- Age- and gender-sensitive rehabilitation plans are essential, with targeted strategies for subgroups like younger females or hemorrhagic stroke patients.
- Health systems should invest in training more physiotherapists and integrate digital approaches (e.g., tele-rehab, robotic devices) to expand reach.
- Clinical guidelines should mandate interdisciplinary care pathways that fuse medical management with structured physiotherapy.

Conclusions

This meta-analytical review confirms that the integration of physiotherapy with standard medical treatment leads to significantly improved outcomes in motor function, cognitive performance, and overall quality of life for stroke patients. These findings underscore the value of multidisciplinary rehabilitation strategies in promoting functional recovery and reducing long-term disability. Importantly, the study highlights that individual factors such as age, gender, and stroke subtype can influence the effectiveness of rehabilitation and should be considered in clinical decision-making. While the overall trends are promising, the variation in physiotherapy protocols, intervention timing, and outcome measurement across studies points to the need for greater standardization. Future research should prioritize longitudinal studies that assess recovery beyond the acute and subacute phases, explore cost-effectiveness. These developments may expand access and enhance adherence, particularly in underserved populations. In summary, the evidence supports the inclusion of structured physiotherapy in stroke rehabilitation pathways, while also calling for rigorous, future-focused research to optimize its implementation across diverse healthcare settings.

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