JHWCR JOURNAL OF HEALTH, WELLNESS AND COMMUNITY RESEARCH 3007-0570

https://doi.org/10.61919/am3wj583

Review Article

Physiotherapy Interventions in Post-Stroke Rehabilitation: A Narrative Review of Contemporary Evidence

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"Cite this Article" Received: 05 April 2026; **Accepted**: 26 May 2026; **Published**: 02 June 2026

Author Contributions: Conceptualization: AAA, SN, NS; methodology: AAA, SN, MK; literature search and data extraction: WZ, NS; analysis and interpretation: AAA, WZ, MK; manuscript drafting and revision: AAA, SN, NS, WZ, MK; critical review and final approval: all authors. **Ethical Approval**: Shaheed Mohtarma Benazir Bhutto Medical University, Larkana, Pakistan **Informed Consent**: Written informed consent was obtained from all participants; **Conflict of Interest**: The authors declare no conflict of interest. **Funding**: No external funding; **Data Availability**: Available from the corresponding author on reasonable request; **Acknowledgments**: N/A.

ABSTRACT

Background: Stroke is a leading cause of long-term disability and is frequently associated with motor impairment, balance dysfunction, gait limitation, reduced endurance, and dependency in activities of daily living. Physiotherapy is central to post-stroke recovery, but the growing range of conventional and technology-assisted interventions requires clinically meaningful synthesis. Objective: This narrative review aimed to synthesize contemporary evidence on physiotherapy interventions used in post-stroke rehabilitation, with emphasis on mechanisms, clinical benefits, evidence strength, and practical implications. Methods: A structured literature search was conducted using PubMed, Scopus, Web of Science, and Google Scholar. English-language literature published primarily between 2005 and 2024 was reviewed, with older landmark publications included where conceptually relevant. Evidence was synthesized narratively across major intervention categories, including task-oriented training, repetitive practice, neurodevelopmental treatment, strength and aerobic exercise, balance and gait training, robotic-assisted therapy, virtual reality, functional electrical stimulation, and constraint-induced movement therapy. Results: The strongest and most consistent evidence supported active, repetitive, task-specific rehabilitation strategies, including task-oriented training, repetitive task practice, strengthening, aerobic exercise, balance training, gait training, and constraint-induced movement therapy in selected patients. Neurodevelopmental treatment demonstrated mixed evidence and appears more appropriate as an adjunct than as an isolated intervention. Robotic-assisted therapy, virtual reality, and functional electrical stimulation showed moderate-to-strong potential as adjunctive modalities, particularly when they increased repetition, feedback, motivation, or task-specific neuromuscular activation. Conclusion: Post-stroke physiotherapy should be individualized, intensive, progressive, and functionally oriented. Core rehabilitation should prioritize evidence-supported active interventions, while technology-assisted and facilitation-based approaches should be integrated selectively according to patient needs, clinical goals, and resource availability. Keywords: Stroke Rehabilitation; Physiotherapy; Physical Therapy Modalities; Neurorehabilitation; Task-Oriented Training; Gait Training; Functional Recovery; Neuroplasticity

INTRODUCTION

Stroke remains one of the leading causes of long-term disability worldwide and continues to impose a substantial clinical, social, and economic burden on individuals, families, and health systems. Survivors commonly experience motor weakness, impaired balance, gait dysfunction, sensory deficits, fatigue, reduced cardiopulmonary fitness, and limitations in activities of daily living, all of which contribute to dependency and reduced quality of life. The burden is particularly pronounced in low- and middle-

income settings, where access to timely and intensive rehabilitation services is often limited. Because functional recovery after stroke depends not only on neurological repair but also on activity-dependent relearning and adaptation, rehabilitation is a central component of post-stroke care (1,2).

Physiotherapy plays a fundamental role in restoring mobility, improving motor control, enhancing balance and walking ability, reducing secondary complications, and promoting functional independence after stroke. Over recent decades, the field has moved from impairment-focused approaches toward more active, task-specific, and patient-centered rehabilitation strategies. Evidence increasingly supports interventions that emphasize repetition, intensity, specificity, progressive strengthening, aerobic conditioning, balance retraining, and meaningful functional practice. At the same time, conventional approaches such as neurodevelopmental treatment remain widely used in clinical settings, despite ongoing debate regarding their comparative effectiveness when applied alone rather than as part of a broader task-oriented rehabilitation program (3–6).

The evidence landscape has also expanded with the introduction of technology-assisted rehabilitation, including robotic-assisted therapy, virtual reality, and functional electrical stimulation. These approaches offer opportunities for high-repetition training, enhanced feedback, improved patient engagement, and targeted activation of impaired movement patterns. However, their clinical utility depends on factors such as patient selection, timing after stroke, severity of impairment, therapist expertise, cost, availability, and integration with conventional rehabilitation. This is particularly relevant in resource-constrained health systems, where expensive technologies may not be widely accessible and where practical, scalable, and evidence-informed rehabilitation models are needed (7,8).

Although multiple clinical trials, systematic reviews, and rehabilitation guidelines have examined specific physiotherapy interventions after stroke, clinicians often require an integrated synthesis that compares conventional and emerging approaches in terms of mechanisms, evidence strength, clinical applicability, and implementation challenges. Existing literature provides strong support for task-oriented and repetitive practice-based approaches, while evidence for some other modalities varies according to intervention dosage, stroke stage, outcome domain, and baseline functional capacity. Therefore, a narrative synthesis is useful for organizing this diverse evidence into a clinically meaningful framework that can guide rehabilitation decision-making and identify areas requiring further research.

This narrative review aims to synthesize contemporary evidence on physiotherapy interventions used in post-stroke rehabilitation, including task-oriented training, repetitive practice, neurodevelopmental techniques, strength and aerobic exercise, balance and gait training, robotic-assisted therapy, virtual reality, functional electrical stimulation, and constraint-induced movement therapy. The review specifically seeks to discuss the mechanisms, clinical benefits, evidence strength, and practical implications of these interventions for improving motor recovery, mobility, functional independence, and quality of life among stroke survivors.

MATERIAL AND METHODS

This article was designed as a narrative review to provide an integrative and clinically oriented synthesis of physiotherapy interventions used in post-stroke rehabilitation. A narrative approach was considered appropriate because the objective was not to produce a pooled effect estimate or exhaustive systematic evidence map, but to summarize and interpret a broad range of conventional and technology-assisted rehabilitation approaches, their proposed mechanisms, evidence strength, and clinical applicability. The review was guided by principles of transparent narrative synthesis, with attention to relevance, clinical importance, and representation of both established and emerging physiotherapy interventions.

A structured literature search was conducted using PubMed, Scopus, Web of Science, and Google Scholar to identify relevant publications on physiotherapy and physical rehabilitation after stroke. The search

focused primarily on English-language literature published between 2005 and 2024, while older landmark publications were considered when they provided foundational concepts or widely cited rehabilitation principles. Search terms included combinations of “stroke rehabilitation,” “post-stroke recovery,” “physiotherapy,” “physical therapy,” “task-oriented training,” “repetitive task practice,” “neurodevelopmental treatment,” “Bobath,” “strength training,” “aerobic exercise,” “balance training,” “gait training,” “robotic rehabilitation,” “virtual reality,” “functional electrical stimulation,” “constraint-induced movement therapy,” and “neuroplasticity.”

Publications were considered relevant if they addressed adult stroke rehabilitation and discussed physiotherapy interventions intended to improve motor recovery, mobility, balance, gait, upper-limb function, functional independence, endurance, or quality of life. Priority was given to clinical guidelines, randomized controlled trials, systematic reviews, meta-analyses, and influential observational or conceptual studies that contributed directly to understanding physiotherapy practice after stroke. Studies were excluded if they focused primarily on pediatric populations, non-stroke neurological disorders, pharmacological treatment, surgical interventions, or rehabilitation approaches outside the scope of physiotherapy. Articles that discussed stroke only indirectly or did not provide clinically relevant information on rehabilitation interventions were also excluded.

The literature was reviewed thematically and organized according to major intervention categories: task-oriented training and repetitive practice, neurodevelopmental techniques, strength and aerobic exercise, balance and gait training, technology-assisted rehabilitation, functional electrical stimulation, and constraint-induced movement therapy. Evidence was interpreted narratively by considering consistency of findings across study types, relevance to clinical practice, proposed mechanisms of action, and applicability across different levels of post-stroke impairment. Where possible, stronger evidence from randomized trials, systematic reviews, and clinical guidelines was prioritized over opinion-based or descriptive literature.

Because this review was narrative rather than systematic, no formal protocol registration, PRISMA flow diagram, meta-analysis, or risk-of-bias assessment was undertaken. The review therefore does not claim exhaustive retrieval of all available studies and may be subject to selection bias inherent to narrative literature synthesis. To reduce this limitation, the review drew from multiple databases, incorporated both contemporary and landmark literature, and emphasized evidence from higher-level study designs where available. The findings are presented as a clinically focused synthesis intended to support understanding of physiotherapy options in post-stroke rehabilitation rather than as a definitive comparative effectiveness ranking.

RESULTS / SYNTHESIS

The reviewed literature indicates that physiotherapy interventions for post-stroke rehabilitation can be organized into three broad categories: established active rehabilitation strategies, conventional neurofacilitation-based approaches, and emerging technology-assisted interventions. The strongest and most consistent evidence supports active, repetitive, task-specific rehabilitation approaches that directly train meaningful functional activities. These include task-oriented training, repetitive task practice, progressive strengthening, aerobic conditioning, balance training, gait retraining, and constraint-induced movement therapy. Technology-assisted interventions, including robotic-assisted therapy, virtual reality, and functional electrical stimulation, appear clinically promising and may enhance treatment intensity, engagement, and motor relearning, but their comparative superiority over well-delivered conventional therapy remains less certain and is influenced by cost, availability, patient selection, and intervention dosage.

Task-oriented training and repetitive practice emerged as central components of contemporary stroke rehabilitation. These approaches are based on the principle that repeated practice of goal-directed functional tasks promotes use-dependent neuroplasticity, improves motor learning, and enhances

functional independence. Evidence from rehabilitation trials and reviews supports their role in improving upper-limb function, lower-limb control, mobility, and activities of daily living, particularly when interventions are intensive, individualized, and linked to real-world tasks. Clinically, these findings suggest that rehabilitation should move beyond isolated impairment correction and prioritize meaningful, repeated practice of activities such as reaching, grasping, sit-to-stand transfer, walking, stair negotiation, and balance-demanding functional tasks.

Neurodevelopmental treatment, commonly represented by the Bobath concept, remains widely used in clinical practice but demonstrates more variable evidence compared with task-specific approaches. The method emphasizes facilitation of normal movement patterns, postural control, and inhibition of abnormal tone. While some studies suggest benefits in movement quality and postural alignment, current evidence does not consistently show superiority over active, task-oriented rehabilitation. Therefore, neurodevelopmental techniques may be most appropriately used as adjunctive strategies rather than stand-alone interventions, particularly when combined with functional practice, strengthening, and gait or balance training.

Strength training and aerobic exercise are important components of post-stroke rehabilitation because muscle weakness, reduced endurance, fatigue, and cardiovascular deconditioning commonly limit functional recovery. Progressive resistance training can improve muscle strength, mobility, and functional performance without necessarily increasing spasticity when appropriately prescribed. Aerobic exercise, including treadmill walking, cycling, and structured endurance training, contributes to improved cardiovascular fitness, walking capacity, fatigue management, and quality of life. These interventions are clinically important because they address both neurological recovery and secondary health risks, including inactivity, cardiovascular disease, and recurrent stroke risk.

Balance and gait training remain essential for reducing disability and improving community mobility after stroke. Balance interventions commonly include static and dynamic postural control activities, weight shifting, anticipatory and reactive balance exercises, and functional stability training. Gait training may include overground walking, treadmill training, body-weight-supported treadmill training, and task-specific locomotor practice. Evidence generally supports these approaches for improving walking speed, endurance, symmetry, stability, and confidence during mobility. Because impaired balance and gait are strongly associated with falls, dependency, and restricted participation, these interventions should be included in most individualized post-stroke rehabilitation plans.

Technology-assisted rehabilitation provides additional opportunities to increase repetition, feedback, motivation, and task intensity. Robotic-assisted therapy can deliver highly repetitive and controlled limb movements, particularly for patients with more severe motor impairment who may struggle to complete sufficient repetitions independently. However, its superiority over dose-matched conventional therapy remains uncertain, suggesting that robotic systems should be viewed as tools for increasing training intensity rather than replacements for therapist-led rehabilitation. Virtual reality offers interactive and motivating environments that may improve balance, motor function, attention, and adherence, especially when tasks are functionally relevant and appropriately progressed. Functional electrical stimulation may support motor relearning by activating weakened muscles during functional tasks and can be particularly useful for improving gait mechanics, foot clearance, and selected upper-limb movements.

Constraint-induced movement therapy has comparatively strong evidence for improving upper-limb use in selected patients with retained voluntary movement. By restricting use of the less-affected limb and encouraging intensive practice of the affected limb, this approach targets learned non-use and promotes cortical reorganization. However, its applicability depends on patient selection, residual motor capacity, tolerance of intensive practice, and adherence to treatment protocols. It is therefore best considered for appropriately screened individuals rather than as a universal intervention for all stroke survivors.

Table 1. Physiotherapy Interventions in Post-Stroke Rehabilitation

Intervention	Core Components	Proposed Mechanism	Main Clinical Benefits	Evidence Strength	Clinical Interpretation
Task-oriented training	Repetitive practice of meaningful functional tasks such as reaching, standing, walking, and transfers	Use-dependent neuroplasticity and task-specific motor relearning	Improves motor function, activities of daily living, and functional independence	Strong	Should be a central component of rehabilitation because it directly targets functional recovery
Repetitive task practice	High-frequency repetition of specific movement patterns	Reinforcement of motor pathways and skill acquisition	Improves upper- and lower-limb function	Strong	Most effective when individualized, intensive, and linked to functional goals
Neurodevelopmental treatment / Bobath	Facilitation of normal movement, postural alignment, and inhibition of abnormal tone	Modulation of tone and improvement of movement control	May improve movement quality and postural control	Moderate / mixed	Useful as an adjunct, but should not replace active task-specific training
Strength training	Progressive resistance exercises for affected and unaffected muscle groups	Increased muscle force generation and neuromuscular activation	Improves strength, mobility, and functional performance	Strong	Can be safely incorporated when appropriately prescribed and monitored
Aerobic exercise	Treadmill walking, cycling, walking programs, and endurance training	Improved cardiovascular fitness, endurance, and neurophysiological adaptation	Improves walking capacity, fatigue, quality of life, and general health	Strong	Important for both neurological rehabilitation and secondary prevention
Balance training	Static and dynamic balance tasks, weight shifting, postural control exercises	Improved proprioception, anticipatory control, and reactive stability	Reduces fall risk and improves postural stability	Strong	Essential for mobility recovery and safe community participation
Gait training	Overground walking, treadmill training, and body-weight-supported treadmill training	Task-specific locomotor retraining and gait symmetry improvement	Improves walking speed, endurance, symmetry, and mobility confidence	Strong	Should be individualized according to gait impairment, endurance, and safety level
Robotic-assisted therapy	Device-assisted repetitive upper- or lower-limb movements	High-intensity, controlled, and repetitive motor practice	May improve motor recovery, especially in severe impairment	Moderate to strong	Best viewed as an adjunct to increase training dose, not as a replacement for conventional therapy
Virtual reality	Interactive simulated rehabilitation environments	Enhanced engagement, feedback, and motor-cognitive integration	Improves balance, motor function, motivation, and adherence	Moderate	Promising where available, but effectiveness depends on task relevance and accessibility
Functional electrical stimulation	Electrical stimulation of muscles during functional movement	Muscle activation, motor relearning, and prevention of disuse	Improves gait mechanics and selected upper-limb functions	Moderate to strong	Useful when integrated with functional task practice rather than used passively
Constraint-induced movement therapy	Restriction of less-affected limb with intensive affected-limb practice	Reduction of learned non-use and cortical reorganization	Improves affected upper-limb function and real-world use	Strong in selected patients	Appropriate for patients with sufficient residual voluntary movement and ability to tolerate intensive practice

Overall, the synthesis suggests that post-stroke physiotherapy should be individualized, intensive, progressive, and functionally relevant. Interventions with the strongest clinical support are those that actively engage the patient in repeated, goal-directed movement practice. Technology-assisted methods may enhance outcomes when they increase repetition, motivation, feedback, or access to task-specific practice, but their implementation should be guided by resource availability and patient suitability. The evidence also indicates that rehabilitation programs should not rely on a single technique; rather,

optimal recovery is likely to require an integrated approach combining task-specific practice, strengthening, aerobic conditioning, balance and gait training, and selected adjunctive technologies when clinically justified.

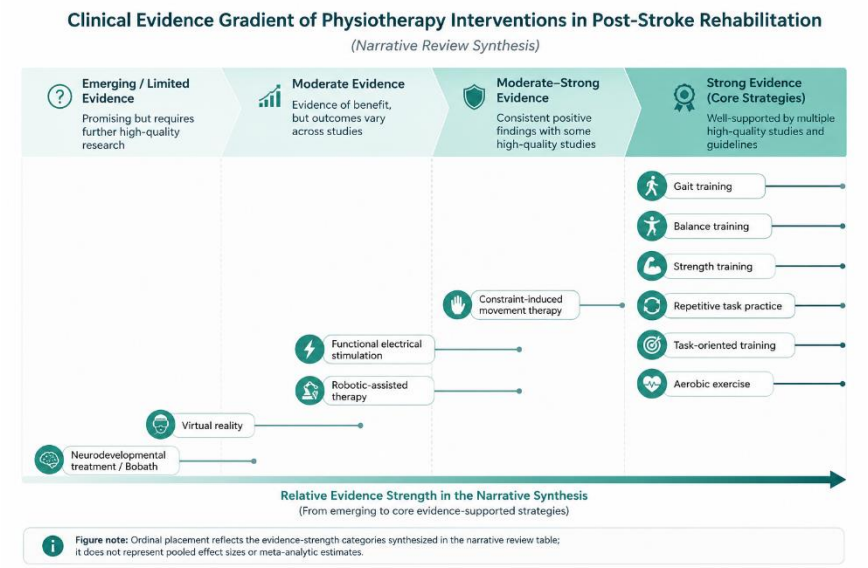

Figure 1. Clinical Evidence Gradient of Physiotherapy Interventions in Post-Stroke Rehabilitation.

This figure presents a conceptual evidence gradient of physiotherapy interventions used in post-stroke rehabilitation, categorizing interventions according to their relative strength of supporting evidence. Task-oriented training, repetitive task practice, strength training, aerobic exercise, balance training, and gait training are positioned as core evidence-supported strategies with the strongest clinical support. Constraint-induced movement therapy occupies an intermediate position with strong evidence in appropriately selected patients, while functional electrical stimulation and robotic-assisted therapy demonstrate moderate-to-strong evidence as adjunctive interventions. Virtual reality and neurodevelopmental treatment (Bobath) are shown within the moderate and emerging evidence spectrum, reflecting greater variability in outcomes and the need for further high-quality research. The figure highlights the progression from emerging approaches to well-established rehabilitation strategies and emphasizes the importance of integrating evidence-based interventions into individualized stroke rehabilitation programs.

DISCUSSION

This narrative review synthesizes contemporary evidence on physiotherapy interventions used in post-stroke rehabilitation and highlights that active, repetitive, task-specific, and functionally meaningful interventions form the strongest foundation for recovery. Across the reviewed literature, task-oriented training, repetitive task practice, strengthening, aerobic exercise, balance training, gait training, and constraint-induced movement therapy showed the most consistent clinical relevance for improving motor recovery, mobility, activities of daily living, and functional independence. In contrast, neurodevelopmental treatment remains widely used but has more mixed evidence when applied as an isolated approach, while technology-assisted interventions such as robotic-assisted therapy, virtual reality, and functional electrical stimulation appear promising as adjunctive strategies that may improve training intensity, engagement, feedback, and motor relearning in selected patients.

The findings align with contemporary rehabilitation principles emphasizing neuroplasticity, task specificity, repetition, intensity, salience, and progressive challenge. Task-oriented and repetitive practice-based interventions are supported by the concept that functional recovery after stroke depends on repeated activation of task-relevant neural circuits and practice of meaningful activities. This supports a shift away from passive or therapist-dominated treatment models toward active rehabilitation in which

patients repeatedly practice clinically relevant movements such as reaching, grasping, standing, walking, stair negotiation, and balance-demanding activities. These approaches are particularly important because gains in isolated impairment measures do not always translate into real-world independence unless rehabilitation directly targets activities needed for daily life (3–6,9).

The role of neurodevelopmental treatment requires cautious interpretation. Although the Bobath concept has historical importance and remains commonly used in clinical practice, the reviewed evidence does not consistently demonstrate that it is superior to task-oriented or impairment-specific active interventions. Its potential value may lie in facilitating postural alignment, movement quality, and tone management as part of a broader rehabilitation program rather than serving as the primary treatment framework. Therefore, clinical programs should avoid relying exclusively on neurodevelopmental techniques and should instead integrate them with strengthening, balance retraining, gait practice, and task-specific functional training where appropriate.

Strength training and aerobic exercise should be considered essential components of post-stroke rehabilitation because they address both neurological and systemic consequences of stroke. Muscle weakness, fatigue, deconditioning, reduced walking endurance, and cardiovascular risk are common after stroke and may restrict participation even when neurological recovery occurs. Progressive resistance training improves force generation and functional performance, while aerobic exercise contributes to endurance, cardiovascular fitness, fatigue reduction, and secondary prevention. These interventions are clinically important because stroke rehabilitation should not only focus on motor recovery but also on long-term health, recurrent stroke risk reduction, and participation in community life (12,13).

Balance and gait training remain central to functional recovery because walking limitation and fall risk are among the most disabling consequences of stroke. The synthesis indicates that static and dynamic balance exercises, weight-shifting activities, postural control training, overground walking, treadmill training, and body-weight-supported gait practice can improve mobility-related outcomes. These interventions should be individualized according to severity of impairment, endurance, balance capacity, and safety level. In clinical practice, gait and balance rehabilitation should also be linked to participation goals such as independent transfers, household mobility, outdoor walking, stair use, and return to social activities.

Technology-assisted interventions provide important opportunities but should be interpreted with appropriate caution. Robotic-assisted therapy may help deliver high-intensity and repetitive upper- or lower-limb movements, especially in patients with severe impairment who cannot independently complete sufficient repetitions. However, the clinical value of robotics appears to depend on whether it increases meaningful practice dose beyond conventional therapy. Virtual reality may improve motivation, engagement, feedback, and motor-cognitive integration, but its effects depend on the relevance of simulated tasks, system accessibility, patient tolerance, and therapist supervision. Functional electrical stimulation may be particularly useful when paired with functional tasks, such as gait training or upper-limb practice, because it provides active neuromuscular stimulation rather than passive treatment. These technologies should therefore be viewed as adjuncts that can enhance rehabilitation intensity and specificity rather than as replacements for therapist-guided, goal-oriented rehabilitation (8,14,16).

Constraint-induced movement therapy has strong clinical relevance for selected patients with residual voluntary upper-limb movement. Its mechanism is based on overcoming learned non-use by restricting the less-affected limb and intensively training the affected limb. However, its success depends on appropriate patient selection, treatment tolerance, adherence, supervision, and sufficient baseline motor ability. This means that CIMT should not be generalized to all stroke survivors but should be applied to carefully screened patients who can safely participate in intensive upper-limb training (15).

This review has several limitations that should be considered when interpreting its findings. As a narrative review, it did not include formal protocol registration, PRISMA-based study selection, risk-of-bias assessment, or meta-analysis. Therefore, the synthesis cannot provide pooled effect estimates or definitive comparative rankings across interventions. The literature selection may also be affected by selection bias, publication bias, and variation in the methodological quality of included studies. Furthermore, stroke rehabilitation evidence is heterogeneous because outcomes vary according to stroke type, lesion location, time since stroke, baseline severity, intervention dose, therapist expertise, and healthcare setting. These factors limit direct comparison between intervention categories and reinforce the need for individualized clinical decision-making.

Clinically, the findings support an integrated rehabilitation model in which physiotherapy programs are individualized, intensive, progressive, and functionally oriented. Core treatment should emphasize task-specific practice, repetitive movement training, strengthening, aerobic conditioning, balance retraining, and gait rehabilitation. Adjunctive approaches such as neurodevelopmental facilitation, robotic therapy, virtual reality, functional electrical stimulation, and CIMT may be added when they match patient goals, impairment profile, resource availability, and clinical feasibility. Future research should focus on defining optimal dosage, timing, intensity, and combinations of interventions; identifying which patient subgroups benefit most from specific approaches; evaluating long-term functional outcomes; and testing low-cost, scalable rehabilitation models suitable for resource-limited settings.

CONCLUSION

Physiotherapy remains a central component of post-stroke rehabilitation and contributes substantially to motor recovery, mobility, functional independence, and quality of life. The strongest support is available for active and functionally relevant interventions, including task-oriented training, repetitive practice, strengthening, aerobic exercise, balance training, gait training, and constraint-induced movement therapy in appropriately selected patients. Technology-assisted interventions such as robotic therapy, virtual reality, and functional electrical stimulation may provide additional benefit when they enhance repetition, feedback, motivation, and task-specific practice, but they should be integrated as adjuncts rather than replacements for individualized therapist-led rehabilitation. Overall, post-stroke physiotherapy should be evidence-informed, patient-centered, intensive, and adaptable to clinical resources, with future research focusing on standardized protocols, long-term outcomes, and accessible models of rehabilitation delivery.

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