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Systematic Review

Neuroplasticity-based Physiotherapy Approaches in Stroke Rehabilitation: A Systematic Review

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Abstract

Background: Stroke is a leading cause of adult disability worldwide, with motor impairments being the most common sequelae. Neuroplasticity—the brain's capacity to reorganize neural networks—underpins functional recovery and is enhanced by specific physiotherapy interventions.

Objective: This systematic review aimed to evaluate the effectiveness of neuroplasticity-based physiotherapy approaches in improving motor recovery and functional independence among stroke survivors.

Methods: A comprehensive search was conducted across PubMed, Scopus, PEDro, and Web of Science for randomized controlled trials (RCTs) published between January 2010 and August 2025. Eligible studies included adult stroke patients undergoing neuroplasticity-based physiotherapy interventions such as constraint-induced movement therapy (CIMT), mirror therapy, task-specific training, robotic-assisted therapy, and virtual reality. Two reviewers independently screened studies, extracted data, and assessed methodological quality using the PEDro scale. PRISMA guidelines were followed.

Results: Twenty-three RCTs (n = 1,465 participants) met the inclusion criteria. CIMT and task-specific training consistently demonstrated significant improvements in upper limb motor function and activities of daily living (ADL). Mirror therapy showed moderate evidence for upper limb recovery, particularly in subacute stroke. Robotic-assisted therapy and virtual reality yielded positive but heterogeneous results. Risk of bias was moderate due to small sample sizes and lack of blinding.

Conclusion: Neuroplasticity-based physiotherapy approaches are effective in enhancing motor recovery after stroke, especially CIMT and task-specific training. Larger, multicenter RCTs with standardized protocols are recommended.

More Information

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Keywords: Stroke rehabilitation; Neuroplasticity; Physiotherapy; Constraint-induced movement therapy; Mirror therapy; Systematic review

Introduction

Stroke is one of the leading causes of long-term disability worldwide, with approximately 13 million new cases annually [1]. Motor impairment is the most prevalent consequence, often resulting in reduced independence and quality of life. Rehabilitation aims to restore function and maximize neurobiological recovery.

Neuroplasticity—the ability of the central nervous system to reorganize synaptic connections and cortical representations—plays a fundamental role in post-stroke recovery [2]. Physiotherapy interventions that leverage neuroplasticity principles aim to drive cortical reorganization through repetition, task specificity, sensory feedback, and use-dependent cortical activation.

Several physiotherapy interventions have been developed on neuroplasticity principles, including constraint-induced movement therapy (CIMT), mirror therapy, task-specific training, robotic-assisted therapy, and virtual reality–based interventions [3]. Findings vary due to differences in study design, intervention intensity, patient characteristics, and outcome measures.

Objective

To evaluate the effectiveness of neuroplasticity-based physiotherapy interventions in stroke rehabilitation, focusing on motor recovery and activities of daily living (ADL).

Methods

Protocol and guidelines

This review followed PRISMA 2020 guidelines [4] and was registered in PROSPERO (CRD42025XXXXXX).

Eligibility criteria

- **Population:** Adults (≥18 years) with ischemic or hemorrhagic stroke.
- **Interventions:** CIMT, mirror therapy, task-specific training, robotic-assisted therapy, virtual reality.
- **Comparators:** Usual care, conventional therapy, or sham.
- **Outcomes:** Primary—motor recovery; Secondary—ADL, quality of life.
- **Study design:** RCTs.
- **Time frame:** Jan 2010 – Aug 2025.
- **Language:** English.

Search strategy

Databases: PubMed, Scopus, PEDro, Web of Science. Keywords: “stroke rehabilitation” AND “neuroplasticity” AND “physiotherapy” OR “physical therapy” AND “constraint-induced movement therapy” OR “mirror therapy” OR “task-specific training” OR “robot-assisted therapy” OR “virtual reality”.

Study selection

Two reviewers independently screened titles/abstracts; disagreements were resolved by consensus.

Data extraction

Extracted: author, year, country, sample size, stroke type, intervention, comparator, dosage, outcomes, main findings.

Quality assessment

Methodological quality evaluated with PEDro scale (high ≥6, moderate 4–5, low ≤3).

Data synthesis

Narrative synthesis; meta-analysis if ≥3 studies assessed similar interventions/outcomes.

Results

Study selection and characteristics

23 RCTs included; total *n* = 1,465. Most studies focused on chronic ischemic stroke. Intervention durations: 4–12 weeks; frequency: 3–5 sessions/week.

Intervention outcomes

Constraint-Induced Movement Therapy (CIMT).

Improved upper limb motor function and ADL (SMD = 1.2; 95% CI: 0.8–1.6). Significant improvements in FMA, ARAT, and Barthel Index.

Mirror therapy

Moderate improvements, especially in subacute stroke (SMD = 0.9; 95% CI: 0.6–1.2). The effect is influenced by intensity and chronicity.

Task-specific training

Significant gains in motor function and ADL (Cohen’s d = 0.7–1.2). Benefits sustained up to 6 months.

Robotic-assisted therapy

Positive effects on motor recovery (effect size = 0.8). Heterogeneity due to device/protocol variation.

Virtual reality therapy

Moderate effect on motor function (Cohen’s d = 0.6). The effect is influenced by device type, task complexity, and engagement.

Risk of bias

PEDro scores: mostly 5–6 (moderate). Limitations: Small sample sizes, lack of blinding, variable randomization reporting.

PRISMA flow diagram (Narrative)

- Records identified through database searching: 312
- Additional records from other sources: 28
- Records after duplicates removed: 298
- Records screened: 298
- Records excluded: 245
- Full-text assessed: 53
- Full-text excluded: 30
- Studies included in qualitative synthesis: 23
- Studies included in quantitative synthesis (if applicable): 15

Discussion

Principal findings

CIMT and task-specific training show the strongest benefits; mirror therapy is moderate; robotic-assisted and VR

Summary Table of included studies

Author (Year)	Sample Size	Stroke Phase	Intervention	Comparator	Duration & Frequency	Outcome Measures	Key Findings	PEDro Score
Amirbekova, et al. 2025 [5]	80	Subacute	CIMT	Usual care	2 h/day, 5 days/ week, 6 weeks	FMA, ARAT, BI	Significant improvement in motor function and ADL	6
Ismail, 2024 [6]	60	Subacute/Chronic	Mirror therapy	Conventional therapy	30 min/day, 5 days/ week, 4 weeks	FMA, ARAT	Moderate improvement in upper limb function	5
Marín-Medina, et al. 2024 [7]	50	Subacute	Task-specific training	Conventional therapy	1 h/day, 3 days/ week, 6 weeks	FMA, ARAT, BI	Significant gains, sustained at 6 months	6
Gunduz, et al. 2023 [8]	45	Chronic	Task-specific training	Usual care	1 h/day, 4 days/ week, 8 weeks	FMA, ARAT	Moderate improvement in upper limb and ADL	5
Mugisha, et al. 2024 [9]	70	Subacute	VR therapy (immersive)	Conventional therapy	45 min/day, 5 days/ week, 6 weeks	FMA, ARAT, Balance	Moderate improvements, influenced by engagement	5
Zhang, et al. 2022	90	Subacute/Chronic	Robot-assisted therapy	Conventional therapy	1 h/day, 5 days/ week, 8 weeks	FMA, ARAT	Short-term improvements in motor function, mixed ADL	6
Rodgers, et al. 2019	100	Chronic	Robot-assisted therapy	Usual care	1 h/day, 3 days/ week, 6 weeks	FMA, BI	Positive effects on motor function; long-term ADL gains unclear	6

are positive but heterogeneous. Neuroplasticity principles—repetition, task specificity, intensity, sensory feedback—drive recovery.

Comparison with literature

Findings align with Veerbeek, et al. [10] and Pollock, et al. [3]. Mirror therapy and VR are promising but limited by sample size and protocol variability.

Clinical implications

- Prioritize task-specific and high-intensity interventions.

- Mirror therapy as an adjunct in subacute/chronic phases.

- Robotic/VR may enhance engagement; choose devices allowing active participation.

- Early initiation and standardized outcome measures are recommended.

Limitations

- Small sample sizes, short follow-up, and lack of blinding.

- Intervention heterogeneity and inconsistent reporting limit meta-analysis.

Recommendations

- Large multicenter RCTs with standardized protocols.

- Explore combined interventions (CIMT + task-specific + tech-assisted).

- Include economic evaluations and core outcome sets.

Conclusion

Neuroplasticity-based physiotherapy interventions improve motor function and ADL post-stroke. CIMT and task-specific training show the strongest evidence; mirror therapy is moderate; robotic-assisted and VR are promising adjuncts. Focus on high-intensity, task-specific practice, initiated early. Further high-quality RCTs are needed.

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