Rehabilitation interventions for persons with upper extremity impairment following neurological disease: scoping review

Intervenciones de rehabilitación em personas com compromisso de las extremidades superiores tras uma enfermedad neurológica: revisión de alcance

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Abstract

Introduction: Neurological diseases are one of the leading causes of disability worldwide, often associated with changes in upper extremity mobility that compromise independence and quality of life. Early and intensive rehabilitation plays a key role in promoting functional recovery.
Objective: To map rehabilitation interventions aimed at people with upper extremity impairment after neurological disease, in the acute and subacute phases, in a hospital setting.
Methodology: The review was conducted according to the methodology of the Joana Briggs Institute for scoping reviews. The search was performed in the MEDLINE (PubMed), CINAHL, Scopus, and Web of Science databases. Data selection and extraction were performed by two independent reviewers.
Results: Seventeen studies published between 2012 and 2025 were included. The interventions identified were grouped into three categories: technological interventions, task-oriented interventions, and interventions based on sensory and visual feedback. Intensive and repetitive training programs, adjusted to the person's functional capacity, predominated, lasting between 2 and 12 weeks and with a frequency of 2 to 7 sessions per week.
Discussion: The diversity of interventions identified reflects the complexity of the recovery process, with different therapeutic modalities often being combined. The variability in the characterization of interventions highlights the lack of standardization, making it difficult to compare results and define parameters.
Conclusions: The evidence reinforces the importance of intensive, repetitive, task-oriented approaches integrated into a multidisciplinary practice. Gaps in the characterization of interventions are highlighted, pointing to the need for more methodologically robust studies.

Keywords

Mobility limitation; nervous system diseases; rehabilitation; upper extremity.

Resumen

Introducción: Las enfermedades neurológicas son una de las principales causas de discapacidad en todo el mundo, a menudo asociadas con cambios en la movilidad de las extremidades superiores que comprometen la independencia y la calidad de vida. La rehabilitación temprana e intensiva desempeña un papel fundamental en la promoción de la recuperación funcional.
Objetivo: Mapear las intervenciones de rehabilitación dirigidas a personas con discapacidad en las extremidades superiores tras una enfermedad neurológica, en las fases aguda y subaguda, en un entorno hospitalario.
Metodología: La revisión se llevó a cabo de acuerdo con la metodología del Instituto Joana Briggs para revisiones exploratorias. La búsqueda se realizó en las bases de datos MEDLINE (PubMed), CINAHL, Scopus y Web of Science. La selección y extracción de datos fue realizada por dos revisores independientes.
Resultados: Se incluyeron diecisiete estudios publicados entre 2012 y 2025. Las intervenciones identificadas se agruparon en tres categorías: intervenciones tecnológicas, intervenciones orientadas a tareas e intervenciones basadas en retroalimentación sensorial y visual. Predominaron los programas de entrenamiento intensivo y repetitivo, ajustados a la capacidad funcional de la persona, con una duración de entre 2 y 12 semanas y una frecuencia de 2 a 7 sesiones por semana.
Discusión: La diversidad de las intervenciones identificadas refleja la complejidad del proceso de recuperación, en el que a menudo se combinan diferentes modalidades terapéuticas. La variabilidad en la caracterización de las intervenciones pone de relieve la falta de estandarización, lo que dificulta la comparación de resultados y la definición de parámetros.
Conclusiones: La evidencia refuerza la importancia de los enfoques intensivos, repetitivos y orientados a tareas, integrados en una práctica multidisciplinar. Se destacan las lagunas en la caracterización de las intervenciones, lo que apunta a la necesidad de estudios metodológicamente más sólidos.

Palabras clave

Enfermedades del sistema nervioso; extremidad superior; limitación de la movilidad; rehabilitación.

Introduction

According to the World Health Organization (2024), spinal cord injury is one of the neurological conditions associated with significant disability worldwide. More broadly, neurological disorders represent an important cause of disability and loss of functional capacity. It is estimated that around 43% of the world's population has experienced some form of neurological disorder during their lifetime, with these conditions considered to have the greatest impact on the functionality and quality of life of those affected (World Health Organization, 2024). Among the most common sequelae associated with these disorders is impaired upper extremity mobility, which compromises the performance of activities of daily living and instrumental activities of daily living, which are essential for independence and social participation (Gao et al., 2022).

Limitations in performing these activities can have a profound impact on a person's independence, self-esteem, and quality of life, in addition to placing a significant burden on informal caregivers, who become more dependent. This dysfunction in their social role can also trigger psychological changes, such as anxiety and depression (Gao et al., 2022).

In this context, rehabilitation interventions are necessary for the recovery of people with neurological diseases, enabling them to cope with their limitations and maximizing the mobility of their upper extremities through the development of their abilities. Several health professionals participate in the rehabilitation of people with these limitations, such as physical therapists and occupational therapists. However, nurses specializing in rehabilitation nursing implement specific therapeutic strategies aimed at recovering upper extremity mobility and readapting to their limitations (Regulamento no392/2019, 2019). Among the most relevant interventions are passive/assisted mobilization of all upper extremity joints (finger, wrist, forearm, elbow, and scapulohumeral), spasticity inhibition techniques, motor coordination and fine motor skills training, as well as body alignment to prevent muscle injuries, such as contractures and deformities. In addition, the Specialist Nurse in Rehabilitation Nursing provides training in activities of daily living, including instrumental activities of daily living, encouraging the person to become independent and reintegrate into society (Ribeiro, 2021).

Considering the exponential increase in the prevalence of neurological diseases and their consequences, such as upper extremity impairment, it is essential to conduct a scoping review to map rehabilitation interventions aimed at people with upper extremity impairment after neurological disease, in the acute and subacute phases, in a hospital setting. This review aims to identify gaps in existing knowledge, guide future research in this area, and provide support for evidence-based clinical practice.

A preliminary search was conducted in PROSPERO, MEDLINE, the Cochrane Database of Systematic Reviews, and JBI Evidence Synthesis in December 2025, and no current or developing scoping protocols or systematic reviews on this topic were identified.

Thus, this review aims to fill the identified knowledge gaps, providing a solid basis for the implementation of evidence-based clinical practices and fostering future research that improves clinical practice and the quality of care for this specific population.

Method

This scoping review was designed to provide a broader overview of rehabilitation interventions described in the literature for people with upper extremity impairment following neurological disease. The review will be conducted in accordance with the JBI methodology for scoping reviews.

This review was registered on the Open Science Framework (OSF) platform on December 30 and is registered with the doi: 10.17605/OSF.IO/EYAFP.

Inclusion criteria

To define the inclusion criteria, we used the acronym PCC (Participants, Concept, and Context), in accordance with the recommendations of the JBI for scoping reviews. Thus, all studies that do not meet the established criteria will be excluded.

Participants

This review focuses on adults (≥ 18 years old) who have suffered from a neurological disease, neither degenerative nor hereditary, in the acute and/or subacute phase, and who present with upper extremity impairment, regardless of severity.

Concept

The concept under study is rehabilitation interventions aimed at the recovery of individuals with upper extremity impairment following neurological disease. The interventions are not limited to approaches by specific professionals and may cover all types of intervention by any healthcare professional.

Context

Studies conducted in a hospital setting, including stroke units or other inpatient services that provide care to people with acute and subacute neurological conditions.

Types of sources

All types of experimental and quasi-experimental studies will be considered, including randomized and non-randomized clinical trials, before-and-after studies, prospective and retrospective studies, and analytical observational studies, such as cohort studies, case-control studies, and cross-sectional studies. The review will also include descriptive observational study designs, such as case series, individual case reports, and descriptive cross-sectional studies for inclusion. Qualitative studies, such as phenomenology, grounded theory, and ethnography, will also be considered.

In addition, systematic reviews that meet the inclusion criteria will also be considered, depending on the research question at hand. Sources of gray literature, such as opinion articles and theoretical texts, may also be included in this scoping review. There were no restrictions regarding publication year, and studies published up to January 2026 were considered for inclusion. The selected languages were Portuguese, English, and Spanish.

Review question

What rehabilitation interventions are used in people with upper extremity impairment after neurological disease in a hospital setting?

Based on the main question, the following secondary questions were formulated:

a) What are the specific characteristics of the rehabilitation interventions used, including their duration, frequency, and intensity?

b) What types of upper extremity stimulation are most frequently identified?

c) What clinical assessment tools are used to monitor the progress of mobility in the impaired upper extremity?

Search strategy

The search strategy was developed in accordance with the JBI guidelines for conducting a scoping review, as described in chapter 10 (Peters et al., 2020), aiming at a broad approach, within the time and resource constraints available, with the objective of identifying published and unpublished primary studies (gray literature), as well as reviews.

The research strategy was divided into three phases. In the first phase, exploratory, an initial limited search will be conducted in the CINAHL, PubMed, Scopus, and Web of Science databases to obtain an initial contextualization of rehabilitation interventions in adults with upper extremity impairment after neurological disease. To this end, an analysis was performed of keywords contained in the titles, abstracts of the articles, and indexing terms used to describe the articles.

In the second phase, the search, the identified keywords will be used, as well as the indexing terms, adapted for each selected database (MeSH and CINAHL Subject Headings), proceeding to obtain the reference list of identified articles and reports, which can be searched for additional studies.

In the third stage, reference search, only the reference lists of sources that were selected from the full text and/or included in the review will be examined.

The studies to be included in this review will be in Portuguese, Spanish, and English. There is no time limit or geographical configuration for the inclusion of studies in this review.

The databases to be used will be MEDLINE (PubMed), CINAHL (EBSCOhost), and Web of Science. The search strategy used is described in detail in Appendix 1.

Eligibility criteria

The selection of studies will be carried out according to the inclusion criteria pre-specified in this protocol. All identified citations will be collected and uploaded to the Rayyan platform (2024 version), with duplicates removed.

The selection of studies is conducted by two independent reviewers. In case of disagreement between reviewers at any stage of the selection process, these will be resolved by consensus or, if necessary, by an additional reviewer. Details of the retrieved articles will be provided.

This process will be described narratively and accompanied by a flowchart of the process, based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) guidelines, which will illustrate the process of research, source selection, duplicates, full-text retrieval, and any additions to the third stage of investigation, data extraction, and presentation of evidence (Tricco et al., 2018).

Data extraction process

Data extraction will be performed by two independent reviewers using a data extraction tool developed specifically for this purpose, using two tables. The first describes the study and the second focuses on rehabilitation interventions and their specificities. This method aims to organize the results found in a logical and descriptive manner, ensuring compliance with the outlined objective of the review.

The extracted data will include detailed information on the characteristics of the sources of evidence (authors and year of publication); type of rehabilitation interventions and their characteristics (duration, frequency, and intensity); type of stimulation performed.

Results

Seventeen articles published between 2012 and 2025 from various countries were included: Portugal (3)(Agostinho et al., 2024; Freitas et al., 2022; Lopes, 2019), Spain (1) (Hortal et al., 2015), Italy (2) (Ceradini et al., 2024; Duret & Mazzoleni, 2017), Germany (1) (Büsching et al., 2018), England (3) (Chatterjee et al., 2019; Morris et al., 2019; Morris & Van Wijck, 2012), Brazil (1) (Suárez-Iglesias et al., 2020), Lithuania (1)(Endzelytė et al., 2025), Korea (1) (Lee et al., 2018), China (1) (X. Chen et al., 2020), Australia (1) (Murdolo et al., 2017), and the United States (2) (Deluzio et al., 2018a; Hakim et al., 2017). This geographic diversity reflects international interest in upper extremity rehabilitation after neurological disease, although with varying levels of development and clinical application of interventions.

The analysis of the selected studies was divided into two tables, which allowed for better visualization of the data obtained and a critical reading of the selected articles, enabling a greater focus on the area.

Table 1 presents the general characterization of the included studies, describing the authors, year of publication, type of study, objectives, clinical assessment instruments used, health professionals involved, and main conclusions.

Figure 1. PRISMA Diagram for the Scoping Review process

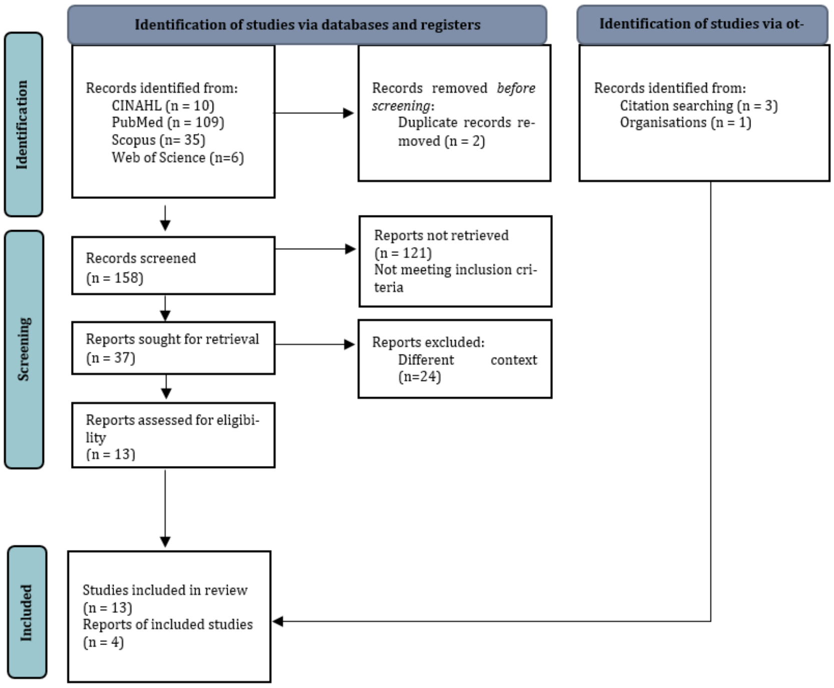

Table 1. Characterization of articles

Authors, year	Study title	Type of study/level of evidence	Objective	Clinical assessment instruments	Health professionals involved	Main conclusions
(Suárez-Iglesias et al., 2020)	Boccia as a Rehabilitation Intervention for Adults With Severe Mobility Limitations Due to Neuromuscular and Other Neurological Disorders: Feasibility and Effects on Upper extremity Impairments	Exploratory pilot study with intervention and control groups, non-randomized/level III	Assess the feasibility of incorporating Boccia as part of a multidisciplinary rehabilitation program for individuals with mobility limitations due to neuromuscular and neurological diseases and describe the effects of the intervention on MS limitations.	• Dynamometer; • Electrical goniometer.	Boccia coach; Regular rehabilitation team.	The program adherence rate was 71.4%, with no adverse effects or injuries associated with the intervention. No statistically significant differences were observed between the two groups in most of the variables analyzed. However, active range of motion (AROM) in wrist flexion and ulnar deviation showed a statistically significant improvement in the boccia group compared to the control group. The authors recommend

						conducting randomized clinical trials with larger samples to confirm these results and establish the effectiveness of the intervention more robustly.
(Duret & Mazzoleni, 2017)	Upper extremity robotics applied to neurorehabilitation: An overview of clinical practice	Narrative review/level V	Present an overview of the use of robotic systems for MS neurorehabilitation.	Not applicable	Physical therapists; Occupational therapists; Professionals trained in robotic therapy.	Rehabilitation robots remain poorly integrated into clinical practice, with the exception of post-stroke rehabilitation. Their application has proven to be safe, allowing for greater intensity, quality, and dosage of treatment when compared to conventional rehabilitation. The use of force fields, multisensory environments, and different feedback modalities contributes to making the rehabilitation process more motivating and engaging.
(Hortal et al., 2015)	Using a brain-machine interface to control a hybrid upper extremity exoskeleton during rehabilitation of patients with neurological conditions	Experimental study/level III	Develop and test a hybrid upper extremity rehabilitation system combining a passive exoskeleton, functional electrical stimulation (FES), and brain-machine interface.	• Motor function – pincer grip, elbow flexion, and shoulder abduction; • EEG; • BMI performance measurement.	Physical therapists; EEG specialists; Clinical engineers.	The integration of brain–machine interfaces, functional electrical stimulation, and exoskeletons is feasible; however, more long-term clinical trials are needed to investigate the actual functional benefits of these approaches.
(Büsching et al., 2018)	Using an upper extremity exoskeleton for semi-autonomous exercise during inpatient	Pilot study/level III	Assess the feasibility and acceptance of semi-autonomous exercises with an exoskeleton for	• Wolf Motor Function Test (WMFT); • Questionnaire on motivation, understanding,	Physical therapists; Occupational therapists.	Participants rated the training program as motivating, enjoyable,

	neurological rehabilitation — a pilot study		upper extremities (ArmeoSpring®) as a complement to the conventional neurological rehabilitation program in an inpatient setting.	satisfaction with training, and willingness to continue.		and clinically acceptable. Significant improvements in proximal upper extremity function were observed, as assessed by the WMFT after four weeks of intervention, with the number of sessions correlating with increased shoulder strength. However, due to the absence of a control group, it is not possible to unequivocally attribute the observed improvements to the additional intervention.
(Ceradini et al., 2024)	Immersive VR for upper-extremity rehabilitation in patients with neurological disorders: a scoping review	Scoping review protocol/ level V	Mapping and synthesizing the use of immersive virtual reality (VR) in upper extremity rehabilitation in people with neurological disorders.	• fugl-meyer assessment – upper extremity (FMA-EU); • box and block test (BBT); • action research arm test (ARAT); • Wolf motor function test (WMFT); • Manual dexterity tests; • Kinematic assessment of movement; • Qualitative measures of function and satisfaction.	Physical therapists; Occupational therapists; Neurorehabilitation professionals.	VR is a promising tool in upper extremity rehabilitation, contributing to increased participant engagement and motivation. It allows for repetitive, task-oriented training, which are fundamental principles of motor rehabilitation. However, there is considerable heterogeneity in intervention protocols, particularly with regard to duration, frequency, and intensity. Consequently, current scientific evidence is limited, and studies with higher methodological quality are needed.

(Hakim et al., 2017)	Rehabilitation robotics for the upper extremity: review with new directions for orthopaedic disorders	Narrative review of literature/level V	Describe robotic rehabilitation devices for the MS, verify evidence of the application of devices in people with MS deficits, and suggest technology that can benefit people with wrist and hand impairments.	Not applicable	Physical therapists; Occupational therapists; Professionals trained in robotic therapy.	There is a growing body of scientific evidence on rehabilitation programs using robotic devices in assisted, resisted, or virtual reality-integrated modalities. Task-oriented therapies, based on principles of control and neuroplasticity, demonstrate greater therapeutic potential when compared to classic rehabilitation approaches. Virtual reality promotes intensive and specific task training, focusing on the wrist and hand. It can be applied to haptic devices, which emphasize training in grasping and manipulating objects.
(Endzelytė et al., 2025)	Integrating Brain-Computer Interface Sysyems into occupacional therapy of enhanced independence of stroke patients: an observational study	Descriptive observational study/ Level IV	Explore the beneficial effects of BCI-based interventions on upper extremity motor function and activities of daily living performance in stroke patients.	• Box and Block Test (BBT); • Nine-hole peg test (9HPT); • Dynamometer; • Functional independence measure (FIM); • Mini-mental state examination (MMSE)	Occupational therapists; Neuro-motor rehabilitation team.	Significant improvements were found in all motor outcomes and functional independence. Grip strength increased significantly for the affected hand. MIF increased, as did cognition throughout treatment, suggesting that BCI interventions in conjunction with conventional occupational therapy may enhance upper

						extremity recovery after subacute stroke.
(Lee et al., 2018)	Effects of robot-assisted terapy on upper extremity function and activities of daily living in hemiplegic patients: a single-blinded, randomized, controlled trial	Randomized controlled trial, single-blind/ Level II	Investigating the effects of robot-assisted therapy on upper extremity function and the ability to perform activities of daily living in patients with stroke-induced hemiplegia.	• Fugl-Meyer Assessment (FMA); • Barthel Index.	Occupational therapists Therapists specializing in robotic rehabilitation Clinical team.	The combination of robot-assisted therapy with general occupational therapy can improve upper extremity function and the ability to perform activities of daily living in this type of population compared to those who only use conventional occupational therapy.
(Chatterjee et al., 2019)	PULSE-I - Is rePetitive Upper extremity SEnsory stimulation early after stroke feasible and acceptable? A stratified single-blinded randomised controlled feasibility study	Randomized, controlled, single-blind clinical trial with two arms/level II	Assess the feasibility, acceptability, safety, and adherence to repetitive sensory stimulation applied to the upper extremity in the first two weeks after stroke.	• Action research arm test (ARAT); • Fulg-meyer assessment (FMA); • Nine-hole peg test (NHPT).	Occupational therapists Physical therapists Clinical team.	The intervention was well tolerated by participants and provided additional benefits. No serious adverse events were reported. There was a trend toward improvement in ARAT, FMA, and NHPT in the experimental group compared to the control group after the intervention, although the differences were not all statistically significant, requiring more robust studies.
(Morris et al., 2019)	Dynamic Lycra® orthoses as an adjunct to arm rehabilitation after stroke: a single-blind, two-arm parallel group, randomized controlled feasibility trial	Randomized controlled clinical trial with two arms, single-blind/level II	Explore the feasibility of conducting a randomized controlled trial of dynamic Lycra® orthoses as a complement to arm rehabilitation after stroke and explore the magnitude and direction of change in arm outcomes.	• Action research arm test (ARAT); • Motor activity log (MAL); • Nine-hole peg test (NHPT); • Motricity index; • Modified tardieu scale.	Occupational therapists Physical therapists Clinical team.	Recruitment and retention of participants were low. There were no clinically relevant effects, but most participants were able to use the orthoses as prescribed.

						More robust studies are needed.
(Morris & Van Wijck, 2012)	Responses of the less affected arm to bilateral upper extremity task training in early rehabilitation after stroke: a randomized controlled trial	Randomized, single-blind clinical trial/level II	Investigate the effects of bilateral training on the dexterity of the ipsilateral arm and on activity limitations; Explain clinical and demographic factors that influence the effects of training; Explain the relationships between contralateral and ipsilateral recovery.	• Fulg-meyer assessment (FMA); • Action research arm test (ARAT); • 9HPT.	Occupational therapists Physical therapists Clinical team	This intervention may lead to minor clinical improvements in ipsilateral performance in tasks requiring fine and rapid dexterity. Younger participants responded better to bilateral training. There was no relationship between contralateral and ipsilateral recovery, suggesting that there may be different causes and mechanisms of recovery.
(Chen et al., 2020)	Efficacy of functional magnetic stimulation in improving upper extremity function after stroke: a randomized, single-blind, controlled study	Randomized controlled trial, single-blind/level II	To clarify the effectiveness of functional magnetic stimulation (FMS) in improving upper extremity hemiplegia in patients with subacute stroke.	• Fulg-meyer assessment (FMA); • Barthel Index.	Occupational therapist Specialists in magnetic stimulation application Blind medical evaluator	Functional magnetic stimulation improves the function of the paretic upper extremity and enhances motor activity recovery more than low-frequency repetitive transcranial magnetic stimulation.
(Murdolo et al., 2017)	Stroke survivors' experiences of using the Graded Repetitive Arm Supplementary Program (GRASP) in an Australian acute hospital setting: A mixed-methods pilot study	Pilot study with mixed design/level IV	Investigate the experiences of stroke patients using the GRASP program applied in the first weeks after stroke in a hospital, including perceptions, benefits, motivation for use, and possible preliminary clinical effects.	• Chedoke arm and hand activity inventory-9) CAHAI-9; • Upper extremity motor assessment scale (UL-MAS); • Stroke impact scale (SIS 3.0).	Occupational therapists Clinical team	Participants used GRASP regularly and reported positive perceptions. Their motivations were the desire to recover, return to previous activities, and leave the hospital earlier. Clinical improvements were observed in CAHAI-9 and UL-MAS, although they were not

						statistically significant. More robust studies are needed.
(Freitas et al., 2022)	Mirror therapy in upper limb rehabilitation after stroke– Case Study (Terapia de espelho na reabilitação do membro superior pós Acidente Vascular Cerebral – Estudo de caso)	Case study/level VI	Identify the gains achieved through the intervention of the rehabilitation nurse using a mirror therapy protocol..	• Mini mental state examination (MMSE); • Motor activity log (MAL); • Disabilitis of the arm, shoulder and hand (DASH); • Hand movement range.	Rehabilitation nurse (EEER).	This therapy promotes improved independence in the functional use of the paretic upper extremity during activities of daily living. Gains in motor skills are observed, reported by the patient themselves as a functional benefit. The authors recommend further studies with larger samples and more robust methodologies in order to consolidate the scientific evidence.
(Lopes, 2019)	Functional rehabilitation of the upper extremity in post stroke patients – a systematic review of the literature (Reabilitação funcional do membro superior em doentes pós AVC — revisão sistemática da literatura)	Systematic review of the literature/level V	Systematically review and summarize the current literature available on prognostic variables related to upper extremity recovery after stroke; Identify the benefits of functional rehabilitation interventions for the upper extremity in patients after stroke.	• Fulg-meyer assessment (FMA); • Action research arm test (ARAT); • Motor activity log (MAL); • Wolf Motor Function Test (WMFT); • Ashworth Scale; • Barthel Index;Electromyogram; • Motor Assessment scale (MAS); • Motricity Index.	EEER; Physical therapist Occupational therapist.	Functional rehabilitation provides benefits such as reduced functional disability, prevention of secondary complications, and encouragement of social participation and independence. Variables such as spasticity, inactivity, and coordination deficits play a decisive role in upper extremity recovery after stroke. The results suggest a positive effect of intensive and specific functional training approaches, particularly when integrated with other

						rehabilitation interventions.
(Deluzio et al., 2018)	Feasibility of early, motor assisted upper extremity cycle ergometry in critically ill neurological patients with upper extremity weakness and variable cognitive status: a case series	Case series/level IV	Description of the safety and feasibility of using a cycle ergometer in critically ill neurological patients with bilateral or unilateral paresis	Pre- and post-cycle ergometer assessment: • Blood pressure; • Average blood pressure; • Heart rate; • Oxygen saturation; • Intracranial pressure; • Glasgow Coma Scale;Coma Recovery Scale-Revised (CRS-R)	Physical therapists; Intensive care specialists	The bilateral cycle ergometer intervention was considered a safe and early intervention for people in the neurocritical ICU.
(Agostinho et al., 2024)	A Rehabilitation Nursing approach in the use of slime in patients with upper limb impairments (Abordagem de Enfermagem de Reabilitação na Utilização de Slime em Pessoas com Alteração dos Membros Superiores)	Descriptive, longitudinal, and quantitative study/level VI	Assess the reduction in spasticity in individuals with impaired upper extremity function, aiming to maximize their functional abilities after intervention with Slime.	• Modified Ashworth Scale; • Medical Research Council Muscle Scale (MRC); • Numerical pain scale; • Barthel Index.	EEEER.	Reduction in spasticity in all participants, increased muscle movement in all cases, and proximal improvements in 57%. Increased independence in self-care, total reduction in pain, and 82% of participants performed the Slime intervention independently or with family support. The degree of spasticity and self-care before and after the Slime intervention was statistically significant. Health indicators were achieved in 100% of cases.

Table 2 summarizes the rehabilitation interventions identified, detailing the type of intervention, its characteristics (duration, frequency, and intensity), the types of stimulation used, and the segment of the upper extremity targeted by the intervention. This allowed for a better comparison of the different approaches described in the literature, facilitating the identification of patterns and similarities.

Table 2. Characterization of interventions

Authors, year	Rehabilitation intervention	Characterization of the intervention (duration, frequency, and intensity)	Type of stimulation	Location of the upper extremity applied
(Suárez-Iglesias et al., 2020)	Boccia intervention Boccia group – Training included warm-up, games, and progressive practice of specific Boccia skills, performed in wheelchairs. Control group – Only conventional multidisciplinary rehabilitation without Boccia sessions.	3 times per week; For 20 weeks; Each week with 2 sessions of 90 minutes and 1 session of 60 minutes, totaling 4 hours/week; The intensity was progressively adjusted to the functional capacity of the participants during the strength, duration, and precision phases.	• Active motor stimulation; • Task-oriented stimulation; • Sensory-motor stimulation.	Upper extremity
(Duret & Mazzoleni, 2017)	Use of assisted and resisted robots, robots with sensory feedback, systems integrated with virtual reality for motor training.	Not applicable	• Sensory-motor stimulation; • Active motor stimulation.	Upper extremity
(Hortal et al., 2015)	Hybrid MS rehabilitation system consisting of a passive exoskeleton (Armeo Spring®) to support the arm, locking the shoulder and wrist and focusing movement on the elbow. - FES applied to the biceps and triceps to produce elbow flexion/extension with stimulation EEG-based BMI with two strategies: - motor imagery (imagining the movement) - detection of movement intention via EEG rhythm.	Each experimental session consisted of several online tests, at least 10 repetitions per task per run with several runs per session.	• Mechanical stimulation; • Visual stimulation.	Elbow
(Büsching et al., 2018)	Training with the Armeo Spring® exoskeleton as an addition to the conventional rehabilitation plan.	Duration: 4 weeks; Up to 6 times per week; 30 minutes per session; 13.2 sessions in 4 weeks (average); 33±8 minutes per session (average per workout); Intensity adjusted according to the person's ability.	• Mechanical stimulation; • Visual stimulation.	Upper extremity
(Ceradini et al., 2024)	Immersive virtual reality Use of head-mounted displays, three-dimensional virtual environments with functional, object-oriented tasks.	2 to 8 weeks duration (average), can be extended up to 12 weeks; 2 to 5 sessions per week, repeated and structured; There is no consensus on ideal intensity parameters.	• Active motor stimulation; • Sensory-motor stimulation; • Task-oriented stimulation.	Upper extremity
(Hakim et al., 2017)	Use of different robotic technologies.	Not applicable	• Task-oriented stimulation; • Active motor stimulation.	Wrist and hand
(Endzelytė et al., 2025)	BCI system (BCI-based recoveriX) integrated into occupational therapy to promote sensory-motor recovery through neural motor feedback. The patient sees a virtual hand move on the computer screen in response to their motor intention.	54 days 15 sessions held 2 to 3 times per week (BCI sessions) Standard occupational therapy – 5 times per week, 50 min per session (bilateral exercises, strengthening, function-oriented tasks).	• Visual stimulation; • Sensory-motor stimulation.	Upper extremity
(Lee et al., 2018)	Robot-assisted therapy applied to the upper extremity that facilitates passive movements and active resistance to improve movement and function.	8 weeks 5 days a week Experimental group – 30 min of robot therapy + 30 min of general occupational therapy (in each session) Control group – 60 min of general occupational therapy in each session	• Mechanical stimulation	Upper extremity
(Chatterjee et al., 2019)	Repetitive sensory stimulation (RSS) is applied through a glove (tipstim glove) that provides repetitive sensory stimulation to the affected upper extremity with the aim of promoting neuroplasticity, improving motor function.	45 minutes per session 5 times a week for 2 weeks	• Sensory-motor stimulation; • Mechanical stimulation.	Hand
(Morris et al., 2019)	Use of dynamic lycra® orthoses, elastic gloves, applied to the affected upper extremity to provide compression, proprioception, and dynamic positioning during daily activities.	Use 8 hours a day Every day of the week For 8 weeks	• Sensory-motor stimulation; • Mechanical stimulation.	Hand

(Morris & Van Wijck, 2012)	Training of bilateral upper extremity tasks involving objects and coordination tasks.	Daily 30-60 min sessions	• Task-oriented stimulation.	Upper extremity
(Chen et al., 2020)	Experimental group - Magnetic stimulation applied with a parabolic coil (MMC-140, Magventure) directly over the extensor muscles of the affected upper extremity Control group - LF-rTMS (transcranial) application of 1Hz to the contralesional motor cortex	Frequency 30 Hz Intensity 20 to 40% of the stimulator's maximum output Control – 1 Hz, 1500 pulses per pressure 2 weeks 1 session per day	• Magnetic stimulation; • Mechanical stimulation.	Fingers and wrist
(Murdolo et al., 2017)	GRASP is a structured program of repetitive and graded exercises based on the practice of repetitive movements and tasks, exercises guided by a manual for use without supervision.	28.44 min (average) Daily training There were no training load parameters; it was self-directed by the patient using the manual.	• Active motor stimulation	Upper extremity
(Freitas et al., 2022)	Mirror therapy where the unaffected limb is reflected to give the illusion of normal movement on the affected side, encouraging visual feedback and neural reorganization.	15 repetitions per exercise; 4 stages of mirror therapy exercise.	• Visual stimulation	Upper extremity
(Lopes, 2019)	Conventional and intensive (MTST, CIMT) to improve motor function and reduce spasticity; Use of electromechanical devices; Vagus nerve stimulation associated with functional rehabilitation; Combination of functional rehabilitation with physical therapy and occupational therapy.	4-12 weeks; 3-7 sessions per week; 30-120 minutes per session, intense training is preferable for significant motor gains; Intensity increases gradually through the complexity of tasks and resistance of movements.	• Active motor stimulation; • Mechanical stimulation; • Sensory-motor stimulation; • Functional electrical stimulation.	Upper extremity
(Deluzio et al., 2018)	Intervention with a cycle ergometer applied bilaterally, positioned on the bed or in front of a chair, adjusted to ensure functional range of motion of the person's shoulder and elbow.	13 sessions 15 minutes (average for each session) 85% of sessions began with passive mobility, and the remainder with active mobility sessions.	• Active motor stimulation; • Mechanical stimulation.	Upper extremity
(Agostinho et al., 2024)	Somatosensory intervention through the use of Slime	5.8 rehabilitation nursing interventions (average); There is no reference regarding frequency and intensity.	• Sensory-motor stimulation.	Hand

The included studies present heterogeneous levels of evidence, distributed as follows:

- Level II – Chatterjee et al., 2019; Chen et al., 2020; Lee et al., 2018; Morris et al., 2019; Morris & Van Wijck, 2012;
- Level III – Büsching et al., 2018; Hortal et al., 2015; Suárez-Iglesias et al., 2020;
- Level IV –Deluzio et al., 2018; Endzelytė et al., 2025; Murdolo et al., 2017;
- Level V – Ceradini et al., 2024; Duret & Mazzoleni, 2017; Lopes, 2019;
- Level IV – Agostinho et al., 2024; Freitas et al., 2022.

Tables 1 and 2 allowed us to group the interventions into three broad categories:

- Technological interventions, including the use of different types of virtual reality (Ceradini et al., 2024; Duret & Mazzoleni, 2017), the use of exoskeletons (Büsching et al., 2018; Hortal et al., 2015), robotic technologies (Hakim et al., 2017), virtual systems (Endzelytė et al., 2025), robot-assisted therapy (Lee et al., 2018), use of gloves (Chatterjee et al., 2019; Morris et al., 2019), magnetic stimulation (X. Chen et al., 2020), electromechanical devices (Lopes, 2019), and cycle ergometers (Deluzio et al., 2018a);
- Task-oriented interventions, such as Boccia training (Suárez-Iglesias et al., 2020), bilateral task training associated with coordination tasks (Morris & Van Wijck, 2012), and repetitive movement programs (Murdolo et al., 2017);
- Sensory and visual feedback interventions, including robots (Duret & Mazzoleni, 2017) from systems integrated into occupational therapy (Endzelytė et al., 2025), repetitive sensory stimulation (Chatterjee et al., 2019), mirror therapy (Freitas et al., 2022), and the use of Slime (Agostinho et al., 2024).

However, some studies combine more than one type of intervention, namely:

- Duret & Mazzoleni, 2017, who combine technological intervention with task-oriented intervention;
- Endzelytė et al., 2025, which combines technological intervention with obtaining neural motor feedback through visualization of the virtual hand on the screen.

Regarding the type of stimulation, the studies included cover:

- Active motor stimulation – Ceradini et al., 2024; S. Deluzio et al., 2018; Duret & Mazzoleni, 2017; Hakim et al., 2017; Lopes, 2019; Murdolo et al., 2017; Suárez-Iglesias et al., 2020;
- Mechanical stimulation – Büsching et al., 2018; Chatterjee et al., 2019; Chen et al., 2020; S. Deluzio et al., 2018; Hortal et al., 2015; Lee et al., 2018; Lopes, 2019;
- Task-oriented stimulation – Ceradini et al., 2024; Hakim et al., 2017; Morris & Van Wijck, 2012; Suárez-Iglesias et al., 2020;
- Sensory-motor stimulation – Agostinho et al., 2024; Ceradini et al., 2024; Chatterjee et al., 2019; Duret & Mazzoleni, 2017; Endzelytė et al., 2025; Lopes, 2019; Suárez-Iglesias et al., 2020;
- Visual stimulation – Büsching et al., 2018; Endzelytė et al., 2025; Freitas et al., 2022; Hortal et al., 2015.
- Two studies specifically refer to magnetic and electrical intervention (X. Chen et al., 2020; Lopes, 2019).

Regarding the site of stimulation, most studies focus on the upper extremity as a whole, but some specify particular segments, namely: hand (Agostinho et al., 2024; Chatterjee et al., 2019)(Hakim et al., 2017; Morris et al., 2019), fingers (X. Chen et al., 2020), wrist (X. Chen et al., 2020; Hakim et al., 2017), and elbow (Hortal et al., 2015).

With regard to the results, all studies report benefits for participants, notably:

- Increased active range of motion in wrist flexion and ulnar deviation (Suárez-Iglesias et al., 2020);
- Demonstration of safety and greater intensity, quality, and dose of treatment with robots integrated into rehabilitation, compared to conventional rehabilitation, with increased motivation among participants (Duret & Mazzoleni, 2017);
- Feasibility of integrating brain-machine interfaces (Hortal et al., 2015);
- Significant improvements in proximal upper extremity functions, with a positive correlation between the number of sessions and increased shoulder strength (Büsching et al., 2018);
- Evidence that virtual reality is a promising tool in upper extremity rehabilitation, increasing participant engagement and motivation (Ceradini et al., 2024);
- Greater therapeutic potential of task-oriented approaches when compared to the classic rehabilitation approach (Hakim et al., 2017);
- Significant improvements in all motor outcomes and functional independence (Endzelytė et al., 2025);
- Superiority of the combination of robot-assisted therapy with occupational therapy over conventional occupational therapy in upper extremity function and activities of daily living (Lee et al., 2018);
- Increased scale scores in the experimental group and good tolerance to repetitive sensory stimulation (Chatterjee et al., 2019);
- High rate of use of prescribed orthoses (Morris et al., 2019);
- Better response to bilateral training in younger participants (Morris & Van Wijck, 2012);

- Greater improvement in function and motor recovery of the affected upper extremity with functional magnetic stimulation compared to transcranial magnetic stimulation (X. Chen et al., 2020);
- Positive perceptions associated with regular use of GRASP, with improvements in CAHAI-9 and UL-MAS (Murdolo et al., 2017);
- Promotion of independence, improvement of motor skills, and functional benefits associated with mirror therapy (Freitas et al., 2022);
- Reduction of functional disability, prevention of secondary complications, and promotion of social participation and independence (Lopes, 2019);
- Safety in the early use of bilateral cycle ergometers in ICUs and neurocritical care units (Deluzio et al., 2018a);
- Reduction of spasticity, increased muscle movement, 57% improvement at the proximal level, increased independence, self-care, and pain reduction with the use of Slime, with statistically significant differences in the degree of spasticity and self-care before and after intervention (Agostinho et al., 2024).

Discussion

The studies identified showed a predominance of narrative literature reviews, scoping review protocols, systematic reviews and pilot studies, controlled experimental studies, and descriptive studies. This distribution shows that the available body of evidence is mostly in an exploratory and descriptive phase, which is typical of emerging areas or areas undergoing rapid technological evolution.

With regard to the healthcare professionals involved, a predominantly multidisciplinary approach was observed, involving physical therapists, occupational therapists, intensive care specialists, nurses specializing in rehabilitation nursing, as well as professionals specializing in rehabilitation technologies, such as clinical engineers and neuroengineering specialists. This diversity reinforces the interdisciplinary nature of upper extremity neurological rehabilitation.

Thus, the rehabilitation of the upper extremity compromised after neurological disease is a multidimensional process that involves different approaches by multidisciplinary teams trained and specialized in their field. The results have shown a wide variety of rehabilitation approaches, reflecting the complexity of this recovery process.

The studies explored specific interventions that are implemented to achieve recovery of the affected upper extremity after neurological pathology, which can be divided into four areas: type of rehabilitation intervention, characteristics of the intervention, type of stimulation, and clinical assessment instruments.

Type of rehabilitation intervention

The studies found present various rehabilitation interventions for the compromised upper extremity, which can be categorized as: technological interventions, task-oriented functional interventions, and interventions based on sensory and visual feedback.

Most studies highlighted the use of technological interventions, such as robots, exoskeletons, haptic devices, virtual reality, orthoses, and brain-machine interfaces, which were widely described, especially in narrative reviews, scoping protocols, pilot studies, and randomized clinical trials. These approaches stand out for their ability to provide intensive, repetitive, and task-oriented training, which are fundamental principles for promoting neuroplasticity. However, their clinical application remains limited by the heterogeneity of devices, technological complexity, and the scarcity of robust studies conducted in a hospital setting, especially in the acute phase (Hortal et al., 2015; Duret & Mazzoleni, 2017; Hakim et al., 2017; Lee et al., 2018; Büsching et al., 2018; Chatterjee et al., 2019; Lopes, 2019; Morris et al., 2019; X. Chen et al., 2020; Ceradini et al., 2024; Endzelytė et al., 2025).

On the other hand, task-oriented functional interventions, such as activity-based rehabilitation, intensive functional rehabilitation, use of the cycle ergometer, and use of recreational activities, show potential for promoting motor and functional gains by integrating active movement, repetition, and functional meaning. This type of intervention requires fewer technological resources, although consistent evidence of their comparative effectiveness is still lacking (Morris & Van Wijck, 2012; Duret & Mazzoleni, 2017; Murdolo et al., 2017; Suárez-Iglesias et al., 2020; Deluzio et al., 2018). This is corroborated by some studies that report that arm cyclometry introduced in the acute phase of the disease, while still in intensive care units, is a safe intervention, and one study demonstrated a significant improvement in physical function using the Barthel Index (Vanderlelie et al., 2024). The early application of this type of intervention reduces myopathy acquired in intensive care and can be applied in bed (Wi et al., 2024).

Interventions based on sensory and visual feedback, such as mirror therapy and Slime intervention, emerge as simple, low-cost, and clinically viable strategies in a hospital setting. In addition, the Slime intervention represents an innovative sensorimotor rehabilitation strategy. Although evidence is still limited, the available results suggest benefits in reducing spasticity, improving movement, and increasing independence in self-care activities, supporting its potential use in early rehabilitation settings (Agostinho et al., 2024).

Although the studies included have limited methodological designs, the results point to benefits in terms of motor perception and functional use of the upper extremity, reinforcing the interest of these approaches in the early stages of rehabilitation (Freitas et al., 2022; Agostinho et al., 2024; Endzelytė et al., 2025).

Characteristics of interventions

It was found that the duration of the programs varied from a few weeks to several months. The frequency ranged from 2 to 7 sessions per week, however, several authors refer to a high frequency, adjusted to the individual, promoting neuroplasticity (Büsching et al., 2018; Chatterjee et al., 2019; Suárez-Iglesias et al., 2020). Several studies also mention that the intervention is characterized by movement repetition (Hortal et al., 2015; Deluzio et al., 2018; Freitas et al., 2022; Ceradini et al., 2024; Endzelytė et al., 2025). The intensity was described in a non-standardized way in most studies. However, some authors describe that the intensity is gradually increased according to the person's capacity or describe it as intense training (Büsching et al., 2018; Lopes, 2019; Suárez-Iglesias et al., 2020).

This heterogeneity makes it difficult to compare interventions and prevents the definition of clear recommendations for clinical practice. Nevertheless, a cross-sectional pattern emerges that values intensive, repetitive, and progressive interventions, adjusted to the person's functional capacity, regardless of the type of approach used.

Types of stimulation

Regarding the types of stimulation, studies have identified a combination of active motor stimulation, sensorimotor stimulation, technology-assisted stimulation, and functional electrical stimulation. Technological approaches have made it possible to integrate multiple stimulation modalities (visual, tactile, proprioceptive, and kinesthetic), enhancing the involvement and motivation of the person undergoing rehabilitation ((Duret & Mazzoleni, 2017; Hakim et al., 2017; Büsching et al., 2018; Lee et al., 2018; Ceradini et al., 2024; Endzelytė et al., 2025).

It was found that most studies do not mention the upper extremity segment in which the intervention is applied, with only four authors specifying the hand (Hakim et al., 2017; Chatterjee et al., 2019; Agostinho et al., 2024), three authors mention the wrist (Duret & Mazzoleni, 2017; Hakim et al., 2017; Chen et al., 2020), one author specifies the fingers (Chen et al., 2021), and one mentions the elbow (Hortal et al., 2015). It can be noted that this is a relevant omission, given that it is necessary to know which segments have the greatest impact on rehabilitation.

Clinical assessment tools

The assessment instruments used in the included studies were mostly standardized motor and functional assessment scales, such as the Box and Block Test (BBT) (Ceradini et al., 2024; Endzelytė et al., 2025), *Fugl-Meyer Assessment* (FMA)(Lee et al., 2018; Chatterjee et al., 2019; Lopes, 2019; Morris et al., 2019; Chen et al., 2021; Ceradini et al., 2024), *Wolf Motor Function Test* (WMFT)(Büsching et al., 2018; Lopes, 2019; Ceradini et al., 2024), *Action Research Arm Test* (ARAT)(Morris & Van Wijck, 2012; Chatterjee et al., 2019; Lopes, 2019; Morris et al., 2019; Ceradini et al., 2024), *Motor Activity Log* (MAL) (Lopes, 2019; Morris et al., 2019; Freitas et al., 2022), Barthel Index (Lee et al., 2018; Lopes, 2019; Chen et al., 2021; Agostinho et al., 2024), Ashworth Scale (Lopes, 2019; Agostinho et al., 2024), and Functional Independence Measure (Endzelytė et al., 2025). This diversity reflects the lack of consensus on the best instrument for monitoring the functional evolution of the upper extremity, although there is a tendency to use combined measures that assess both motor performance and functional use in activities of daily living.

It should be noted that, given the nature of neurological pathology, there are studies that assess the neurological component of these individuals during the intervention, using the Glasgow Coma Scale, Mini Mental State Examination (MMSE), and Coma Recovery Scale-Revised (CRS-R) (Deluzio et al., 2018; Freitas et al., 2022; Endzelytė et al., 2025).

Implications for clinical practice

From a clinical practice perspective, the results of this scoping review reinforce the importance of a multidisciplinary approach, in which different health professionals contribute in an integrated manner to upper extremity rehabilitation. Most studies involve physical therapists and occupational therapists. The role of nurses specializing in rehabilitation nursing is also noteworthy, particularly in the implementation of functional, early, and person-centered interventions (Freitas et al., 2022; Agostinho et al., 2024).

As strengths, this study presents a rigorous and systematic methodology, developed in accordance with JBI recommendations, as well as a comprehensive mapping of all existing literature on the subject under study, including a diversity of rehabilitation interventions. Additionally, these interventions were detailed in depth for a better understanding of the phenomenon under analysis, which may facilitate the development of future research.

However, limitations of this review include gaps in knowledge in this area, such as the scarcity of available studies, the predominance of studies with small samples, the inclusion of studies with lower levels of evidence, and the lack of standardization of intervention parameters, particularly with regard to intensity, frequency, and duration. In addition, the inclusion of articles only in Portuguese, English, and Spanish may have limited the integration of some relevant studies published in other languages.

Conclusions

This Scoping Review provided answers to the research question and deepened understanding of the phenomenon under study.

The results showed a wide variety of rehabilitation interventions aimed at upper extremity recovery after neurological pathology, ranging from technological approaches, task-oriented interventions, and sensory and visual feedback strategies, reflecting the complexity of this recovery process. However, across the board, the interventions emphasize intensive, repetitive, task-oriented training tailored to the person's functional capacity, with rehabilitation playing a key role in optimizing functional recovery and reducing motor deficits.

Future research should focus on improving the characterization and standardization of intervention parameters, particularly regarding intensity, frequency and duration.

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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