
Activity-based Rehabilitation Interventions of the Neurologically Impaired Upper Extremity: Description of a Scoping Review Protocol

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Introduction: A scoping review provides a means to synthesize and present a large body of literature on a broad topic, such as methods for various upper extremity activity-based therapy (ABT) interventions. **Objectives:** To describe our scoping review protocol to evaluate peer-reviewed articles focused on ABT interventions for individuals with neurologically impaired upper extremities. **Methods:** At Jefferson College of Health Professions and Sidney Kimmel Medical College at Jefferson, Philadelphia, the authors will follow this protocol to conduct a scoping review by establishing a research question and conducting a search of bibliographic databases to identify relevant studies. Using specific inclusion and exclusion criteria, abstracts will be screened and full-text articles will be reviewed for inclusion in charting, summarizing, and reporting results of appropriate studies. **Conclusion:** This protocol will guide the scoping review process to develop a framework for establishing a noninvasive ABT intervention informed by evidence for individuals with neurologically impaired upper extremities. **Key words:** activity-based rehabilitation, neurorehabilitation, scoping review, spinal cord injury, tetraplegia, upper extremity

Activity-based rehabilitation, or activity-based therapy (ABT), interventions focus on functional and task-specific activities characterized by high intensity and high repetition with the goal to promote neuroplasticity and recovery following neurologic injury.^{1,2} Several studies have demonstrated that high intensity and repetitive practice interventions by themselves can minimize impairment and improve function.³⁻⁵ To further augment neuroplasticity, others have included additional strategies such as neuromuscular electrical stimulation (NMES), transcranial magnetic stimulation (TMS), and upper extremity (UE) robotic devices to the high-intensity–high-repetition ABT.^{3-4,6}

ABT interventions are frequently offered in large rehabilitation programs specializing in neurologic care and are used across many neurological diagnoses.^{1,2} However, due to the high cost of equipment, high staff burden, and increased

time commitment required of both therapy staff and patients, they are not widely available to individuals with neurological conditions. Moreover, emerging literature on ABT describes dosage recommendations (frequency per week, number of repetitions per session, etc) that may not always be achievable due to factors such as reimbursement and payment barriers and the need to attend to additional rehabilitation goals. Despite the literature²⁻⁶ on ABT interventions focusing on the UE, arm and hand function, there are wide variations in treatment specifications including type of orthosis or robotic, number of repetitions, frequency, duration, and intensity of treatment. Likewise, endpoints of treatment are evaluated using a variety of outcome measures, limiting our understanding about which ABT interventions work best, for whom, and to what endpoint.

Following a spinal cord injury (SCI), arm and hand control is often impaired resulting in

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significant functional limitations. Individuals with tetraplegia report their quality of life would be significantly impacted by improvements in arm and hand function.⁷ SCI results in difficulties in reaching and grasping that until recently were thought to be permanent, however ABT interventions demonstrate change and improvement.³⁻⁵ Although, recovery of UE function is a priority in rehabilitation following SCI, evidence in support of interventions to improve UE function need to be further understood. For example, individuals with UE impairment due to SCI would likely benefit from an ABT UE intervention program that they could perform in the home, using affordable, low-technology alternatives to the high-cost, high-technology ABT interventions often utilized in rehabilitation facilities. Given the wide variation in ABT interventions for the UE, we plan to conduct a formal scoping review of the literature with the goal of establishing a home-based ABT intervention for persons with cervical SCI that is informed by existing evidence.

A scoping review is a method to synthesize and present a large body of literature on a broad topic⁸ and to evaluate a wide variety of research studies.⁹ Scoping reviews use systematic methods^{10,11} and are becoming more prominent as a methodology.⁸ A scoping review works well to evaluate heterogeneous and complex literature.¹² The literature surrounding ABT is diverse in focus, design, and research level, as it involves numerous interventions without a standard dose and varying clinical presentations between and within various neurological conditions. Evaluating ABT literature via scoping review will help us understand the diversity in approaches, populations studied, and outcomes assessed. Although the final outcome is to develop an intervention specific to individuals with incomplete SCI, by including a variety of neurological conditions such as stroke, cerebral palsy, traumatic brain injury, and multiple sclerosis in this scoping review, we will be able to evaluate existing ABT protocols for promoting neuroplasticity and potential devices. The impairments and functional limitations that result from a disorder and/or incident involving the nervous system may be similar in presentation and are often clinically addressed based on that

presentation as opposed to a diagnosis-specific intervention. Persons with mobility limitations due to central neurological conditions such as stroke may have similar difficulties attending outpatient therapy programs. Information on intensity of outpatient ABT programs and success of home-based programs in these populations will inform our efforts to develop protocols for persons with incomplete cervical SCI. Differences exist among persons with these conditions as well; for example, stroke is typically unilateral while SCI is bilateral. We will exclude approaches such as mirror therapy that would not be applicable to cervical SCI. Therefore, the objective of this article is to describe a scoping review protocol to evaluate peer-reviewed literature focusing on ABT interventions for individuals with neurologically impaired UEs.

Methods

This scoping review protocol is based on the methodological framework of Arksey and O'Malley¹⁰ with further refinement by Levac¹¹ (**Figure 1**). There are five required steps when conducting a scoping review: (1) identifying the research question, (2) identifying relevant studies, (3) study selection, (4) charting the data, and (5) collating, summarizing, and reporting results. The sixth step, consultation, is optional.

Step one: Identifying the research question

As described in **Figure 1**, step one of a scoping review involves articulating the research question, including defining the concept, the population, and the outcomes of interest.⁵ The primary research question of this scoping review is “What activity-based therapy interventions are being implemented for upper extremity neurorehabilitation?” Objectives underlying this research question include (a) identifying noninvasive ABT interventions to augment and facilitate neuroplasticity of the UE (b) to understand which noninvasive methods appear to be effective, for what aspect of the UE, and for whom; (c) identifying how endpoints of UE ABT interventions are being evaluated; (d) identifying the facilitators and barriers to implementing UE

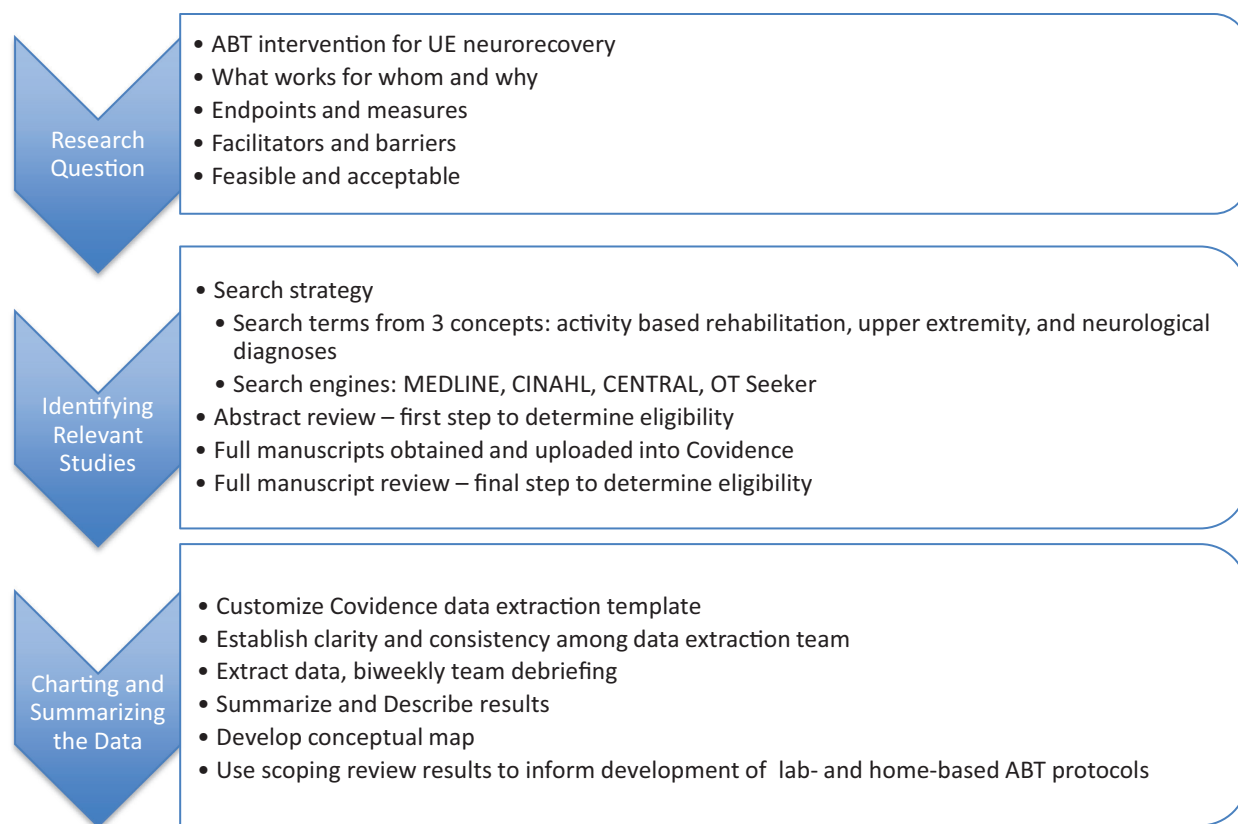


Figure 1. Scoping review protocol schematic. ABT = activity-based rehabilitation; UE = upper extremity.

ABT interventions in the clinic and in the home; and (e) identifying low-cost, low-burden, and low-tech ABT interventions that appear to be effective, can be transferred to the home, and are acceptable to end users.

Steps two and three: Identifying relevant studies and study selection

Search terms and search strategy

An experienced librarian (G.K.) will develop and execute a search strategy to identify relevant literature; no repeat searches will be conducted. The search will include the following limits: humans only, English only, and the year 2000 to current. As shown in **Figure 2**, we will search for the intersection of terms for three concepts: activity-based rehabilitation, upper extremity, and neurological diagnoses. Terms for activity-based rehabilitation will include activity based, repetitive

task training, task specific training, neurological rehabilitation, neurorehabilitation, rehabilitation, prehensile, reach, or grasp. Upper extremity terms will include upper extremity, upper limb, arm, shoulder, elbow, forearm, hand, wrist, or finger. Neurological diagnosis terms will include spinal cord injuries, stroke, cerebral palsy, brain injuries, multiple sclerosis, amyotrophic lateral sclerosis, or quadriplegia. Controlled vocabulary terms will be identified for each database. See **Table 1** for the MEDLINE strategy. The search terms may be modified once the search has commenced. The following bibliographic databases will be searched with limits described above in this scoping review: Ovid MEDLINE including Epub Ahead of Print and In-Process & other Non-Indexed Citations, EBSCOhost Cumulative Index to Nursing and Allied Health Literature (CINAHL), the Cochrane Central Register of Controlled Trials (CENTRAL), and OTseeker. The abstracts from literature included will be uploaded into Covidence, an

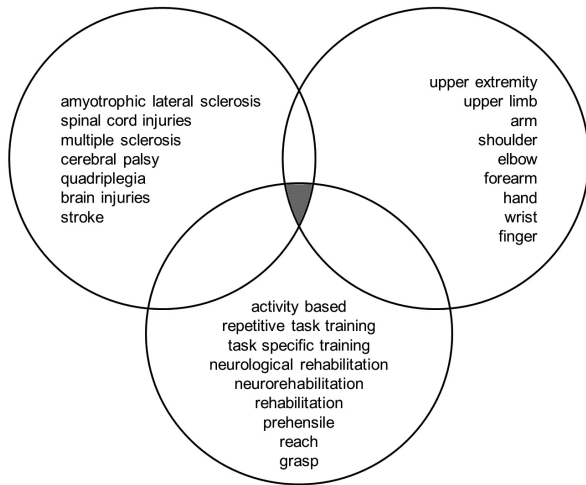


Figure 2. Search strategy terms.

online tool developed for systematic reviews, to remove duplicates and manage the screening and data extraction process. Additionally, we will search for dissertations, theses, and book chapters using ProQuest Dissertation Express, Scopus, and various academic institutional repositories such as the University of Southern California Digital Library, Indiana University ScholarWorks, and MIT DSpace.

Inclusion and exclusion criteria

Inclusion and exclusion criteria for the abstract screen and full-text review phases of study selection are included in **Table 2**. Keeping with scoping review methodologies, inclusion and exclusion criteria may be modified during the scoping review process as determined by the research team.

Study eligibility

Screening for study eligibility will be conducted in a two-step process. First, using the abstract screen criteria (**Table 2**), content of the abstract, title, and year of publication will be screened, independently, by one study team member (C.C.T., R.J.M., S.D., M.J.M.) and one trained occupational or physical therapy graduate student to determine whether the study appears to meet the selection criteria. Abstracts meeting selection criteria will advance to full-text review. If conflicts arise, a senior investigator (R.J.M., M.J.M.) will resolve them.

Table 1. MEDLINE search strategy

No.	Searches
1	exp Spinal Cord Injuries/
2	spinal cord injur*.ti,ab.
3	exp Spinal Cord Diseases/
4	spinal cord dysfunction.ti,ab.
5	exp Stroke/
6	stroke.ti,ab.
7	strokes.ti,ab.
8	cerebral vascular accident*.ti,ab.
9	exp Brain Injuries/
10	brain injur*.ti,ab.
11	Cerebral Palsy/
12	cerebral palsy.ti,ab.
13	exp Multiple Sclerosis/
14	multiple sclerosis.ti,ab.
15	amyotrophic lateral sclerosis.ti,ab.
16	Quadriplegia/
17	quadripleg*.ti,ab.
18	quadripare*.ti,ab.
19	or/1-18
20	exp Upper Extremity/
21	(upper adj3 (limb or extremity)).ti,ab,sh,kf.
22	(arm or shoulder or elbow or forearm or (hand not ("on the other hand" or "hand search*")) or wrist or finger or fingers).ti,ab,sh,kf.
23	or/20-22
24	23 and 19
25	Activity based.ti,ab.
26	((repetitive or specific) adj3 task adj3 (training or practice)).ti,ab.
27	Neurological Rehabilitation/
28	Neurorehabilitation.ti,ab.
29	rehabilitation.ti,kf,fs.
30	(reach* not (reach* adj2 statistical*)).ti,ab,kf.
31	grasp*.ti,ab,kf.
32	prehensi*.ti,ab,kf.
33	or/25-32
34	24 and 33
35	Animals/ not Humans/
36	34 not 35
37	limit 36 to english
38	limit 37 to yr="2000 -Current"
39	remove duplicates from 38

Note: Database(s) searched include Ovid MEDLINE^(R), Ovid MEDLINE^(R) Daily, Epub Ahead of Print, and In-Process & Other Non-Indexed Citations.

Table 2. Inclusion and exclusion for abstract screening and full-text review for eligibility

	Abstract screen	Full-text review for eligibility
Inclusion	Activity-based program: intensive, repetitive, and task-specific training	Randomized controlled trial, case series, pre-post studies
	Involving the upper extremity	Adults and/or adolescents age 13 and older
	Study written in English	Targets upper extremity function defined as shoulder and below, in isolation or in combination
	Study involves only humans	Intervention at least 3 times per week
	Neurologic condition affecting the upper extremity; if SCI, must be tetraplegia	Intervention at least 2 weeks
	Study describes an intervention focused on recovery of motor or sensory function of the shoulder, arm, and/or hand, unaided by surgical intervention	
	Robotics used in conjunction with activity-based rehab or take specific training	
Exclusion	Focus is on walking or lower extremity function	Cross-sectional studies or secondary analysis of study outcome
	Observational only	Only children age 12 and younger
	Intervention is a neuroprosthesis unless part of a training program	Acute injury/disease defined as <3 months
	Brain-computer interface	Routine rehabilitation
	Review article	Range of motion, strengthening, or spasticity training without functional training
	Subjects do not have upper extremity neurological deficits	Mirror therapy
	Intervention is conducted only once	Proof of concept/prototype
	Constraint-induced therapy without a training program	One time intervention
	Traditional or usual therapy only	
	Robotics without activity-based training	
	Neurorecovery of the lower extremities or trunk function	
	Functional electrical stimulation alone	
	Tendon or nerve transfers	
	Brain controlled interface alone	

For studies moving to full-text review, a trained occupational therapy graduate student will obtain the full-text article and upload it into Covidence. Each full-text article will be reviewed using the full-text review for eligibility criteria (Table 2) independently, by trained occupational or physical therapy graduate students and one research team member (C.C.T., R.J.M., S.D., M.J.M.).

Conflicts will be resolved by senior research team members. Reasons for excluding full-text articles will be recorded in Covidence, and studies that meet eligibility will move to step four.

Steps four and five: Charting the data and collating, summarizing, and reporting results

Full-text data extraction team

The data extraction team will consist of the principal (R.J.M.) and senior (M.J.M.) investigators, one physical therapist (C.C.T.), one certified hand therapist who is licensed as both an occupational and physical therapist (S.D.), and two doctoral-level occupational therapists, with at least 10 years of experience in clinical practice and/or research in neurorehabilitation. The data extraction team

will meet to customize a data collection template in Covidence, based on variables described in **Table 3**. Using this template, each team member will extract data from an initial 10 studies – five studies as the primary extractor and five studies as the secondary extractor. The data extracted from the 10 studies will be reviewed for consistency, and the team will discuss reasons for discrepancy between extractors and refine definitions and processes as needed for clarity. This process may occur more than once if necessary. Once the agreement for processes and consistency in data extraction are demonstrated, data from each study will be extracted and charted in Covidence by two members of the data extraction team. The secondary extractor will establish final consensus for each data variable. Team meetings will occur bi-weekly throughout the data extraction phase to monitor progress.

Once data extraction from every study is complete, results will be exported from Covidence to Excel. Summary and descriptive statistics will be used to examine and quantify types of interventions,

frequency, intensity and duration parameters, intervention endpoints, clinical populations, and methods of assessment. Conceptual mapping^{13,14} will be used to identify relationships among interventions, outcomes, and samples. It will also be used to thematically describe low-tech and high-tech approaches to ABT, gaps in outcomes, and barriers and facilitators to feasibility of and satisfaction with ABT. Data will be used to answer the scoping review questions and objectives. The findings will be presented to an external advisory panel to inform development, implementation, and evaluation of lab- and home-based ABT. The final results will be published in a peer-reviewed journal.

Implication of Scoping Review

This scoping review protocol will guide a formal review of the literature on UE ABT in clinical samples with neurological conditions from which specificities about interventions such as dosage,

Table 3. Data extraction form contents

Section	Variables included	Description
Identification	Study details	Sponsorship, country, setting
	Corresponding author information	Name, institution, email, address
	Additional information	First author if different from corresponding
Methods	Design	Type of study design: randomized controlled trial, case series, parallel group versus crossover, etc.
Population	Study criteria and baseline group differences	Inclusion and exclusion criteria
	Baseline characteristics	Age, race, ethnicity, gender, diagnosis, length of time since disease/condition onset
Interventions	Type	CIMT, virtual reality, gaming, robotics, task specific (with FES, gaming, virtual reality etc), intent to imitate, sensory-motor, conventional therapy
	Description of intervention	Brief description, dosing, repetitions setting, other
Outcomes	Outcome name	Standardized performance measure, kinematic analysis, impairment measure, quantity or quality of movement, self-reported outcome, other
	Outcome type	Continuous or dichotomous
	Reported as	Continuous outcomes reporting to include: total number of participants, baseline and endpoint data (or change), statistic and <i>p</i> value, comments Dichotomous outcomes reporting to include: total number of participants, improvement (Y/N), comments

Note: CIMT = constraint-induced movement therapy; FES = functional electrical stimulation.

equipment, set-up requirements, and outcomes will be examined. Although our intent is to use the results of the scoping review to inform UE ABT protocols for home use by persons with SCI, studies with clinical samples other than SCI will also be reviewed owing to the likelihood that many interventions used with persons with stroke, cerebral palsy, traumatic brain injury, and multiple sclerosis can inform protocol development for persons with SCI. The results of this scoping review have the potential to impact care of the impaired UE due to SCI and current neurorehabilitative practice and will be of interest to rehabilitation professionals seeking to implement economic yet effective UE ABT interventions in the home setting.

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