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Concise Arm and Hand Rehabilitation Approach in Stroke (CARAS): A practical and evidence-based framework for clinical rehabilitation management

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Concise Arm and Hand Rehabilitation Approach in Stroke (CARAS): A practical and evidence-based framework for clinical rehabilitation management

Abstract

The volume of information on new treatment techniques supporting the restoration of arm-hand function (AHF) and arm-hand skill performance (ASHP) in stroke survivors overwhelms therapists in everyday clinical practice when choosing the appropriate therapy. The Concise Arm and Hand Rehabilitation Approach in Stroke (CARAS) is designed for paramedical staff to structure and implement training of AHF and AHSP in stroke survivors. The CARAS is based on four constructs: (a) stratification according to the severity of arm–hand impairment (using the Utrecht Arm/Hand -Test [UAT]), (b) the individual's rehabilitation goals and concomitant potential rehabilitation outcomes, (c) principles of self-efficacy, and (d) possibilities to systematically incorporate (new) technology and new evidence-based training elements swiftly. The framework encompasses three programs aimed at treating either the severely (UAT 0-1), moderately (UAT 2-3), or mildly (UAT 4-7) impaired arm-hand. Program themes are: taking care of the limb and prevention of complications (Program 1), task-oriented gross motor grip performance (Program 2), and functional AHSP training (Program 3). Each program is preceded and followed by an assessment. Training modularity facilitates rapid interchange/adaptation of sub-elements. Proof-of-principle in clinical rehabilitation has been established. The CARAS facilitates rapid structured design and provision of state-of-the-art AHF and ASHP treatment in stroke patients.

Comments

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Keywords

arm, hand, self-efficacy, stroke, therapy, task-oriented training

Cover Page Footnote

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Credentials Display

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Approximately 50% of stroke survivors experience unilateral motor deficit that leads to chronic upper extremity impairment. This results in limited functional use of the affected arm as well as reduced engagement in community life (Broeks, Lankhorst, Rumping, & Prevo, 1999; Johansson, Mishina, Ivanov, & Björklund, 2007; Lai, Studenski, Duncan, & Perera, 2002; Pang, Harris, & Eng, 2006; Wolfe, 2000; World Health Organization [WHO], 2001) and a poorer quality of life overall (Nichols-Larsen, Clark, Zeringue, Greenspan, & Blanton, 2005). Four years after stroke, 67% of stroke survivors with initial unilateral motor deficit still experience nonuse or disuse of the affected arm as a major problem (Broeks et al., 1999).

Motor rehabilitation aimed at arm-hand performance after stroke has changed substantially over the last decades. Previously, treatment mainly targeted the International Classification of Functioning, Disability and Health (ICF) function level (WHO, 2001). Researchers now focus instead on ICF activity and participation level. Well-explored training approaches have emerged (Albert & Kesselring, 2012; Brewer, Horgan, Hickey, & Williams, 2013; Hömberg, 2013; Langhorne, Bernhardt, & Kwakkel, 2011) that address paresis and impaired motor control (Dobkin, 2004; Shepherd & Carr, 2005; Sterr, Szameitat, Shen, & Freivogel, 2006). These approaches feature training elements such as meaningfulness; challenge; specificity; feasibility; and, when some arm-hand dexterity emerges, task-oriented and high-intensity training (Peppen et al., 2004). Further, these treatment programs include a wide variety of exercises that stroke survivors may use in therapeutic and/or home-based situations (Arya et al., 2012; Combs, Kelly, Barton, Ivaska, & Nowak, 2010; Davis, 2006; Harris, Eng, Miller, & Dawson, 2009; McDonnell, Hillier, & Esterman, 2013; Platz, 2004). Task-oriented training (French et al., 2007; Timmermans, Seelen, Willmann, Bakx, et al., 2009; Winstein et al., 2004) and constraint-induced movement therapy (Wolf et al., 2008) focus on both the ICF activity level and participation level. In task-oriented approaches, patients are trained in specific functional, skill-related tasks, preferably using real-life objects (Timmermans, Seelen, Willmann, Bakx, et al., 2009), thereby teaching patients to solve specific problems related to issues such as anticipatory locomotor adjustments or cognitive processing by using efficient goal-oriented movement strategies (Timmermans, Seelen, Willmann, & Kingma, 2009; Winstein & Stewart, 2006). The positive transfer of learned skills to other (non-trained) skills occurs when similarities with the learned skill are present (Magill, 2007). Functional treatment outcome in task-oriented training approaches is higher than in muscle strength training (Van Peppen et al., 2004).

The increasing amount of evidence and studies related to arm-hand performance after stroke creates a new problem for modern day therapists treating stroke survivors. The sheer volume of information on new treatment techniques and technologies that could enhance functional recovery or restoration of arm-hand function and arm-hand skill performance may overwhelm therapists in day-to-day clinical practice when they have to choose the appropriate therapy for a patient. This potentially leads to the implementation of a patchwork of training regimens. Translating the latest scientific evidence and results from clinical trials into clinically useful treatments is difficult (Berwick, 2003; Cheeran et al., 2009; Nutley, Walter, & Davies, 2003), and although formal (national) guidelines for training exist, these recommendations cannot always keep up with the latest evidence, especially given the speed of technological developments (Herzlinger, 2006).

In order to guide therapists in systematically designing a stroke patient's arm-hand rehabilitation program, the authors address four issues:

- The heterogeneity of the patient population and the associated patterns and levels of recovery of arm-hand skill performance (Hayward, Barker, & Brauer, 2010; Nijland, van Wegen, Harmeling-van der Wel, & Kwakkel, 2010; van der Lee et al., 2001).
- The lack of adequate description and adaptation of treatment protocols for stroke survivors experiencing a broad variety of problems in daily life related to an impaired arm-hand.
- The encouragement of patients' beliefs about their ability to influence their level of performance, thus enabling them to train at and maintain a certain skill level. This makes the patient the main stakeholder in his or her training (Bandura, 1994; Jones & Riazi, 2010; Kristensen, Persson, Nygren, Boll, & Matzen, 2011).
- The difficulty of swiftly implementing new insights into current and future therapy regimens (Brewer et al., 2013; Langhorne et al., 2011).

The authors propose four potential solutions to these issues:

- The presence or absence of dexterity in the affected arm-hand is the most important variable. When selecting the potentially most effective treatment, the recommendation is to stratify patients with an impaired arm-hand into a limited number of dexterity levels (Langhorne et al., 2011; Nijland et al., 2010).
- A well-described program offering stepwise, comprehensible procedures may facilitate transparency and could lead to outcomes that are more predictable. A (modular) program should span the full range of arm-hand impairments and related functional problems experienced, from taking care and prevention to high-intensity, task-oriented training.
- The patient's lack of engagement with arm-hand treatment may be overcome by using self-efficacy principles, which could also facilitate optimal transfer and retention of learning.
- To allow for quick adaptations to novel and effective innovations, the training content should be based on simple, easy-to-replace schedules organized into time blocks. When necessary, other training methods can replace these schedules' content without having to rearrange treatment planning.

The aim of this paper is to present the Concise Arm and Hand Rehabilitation Approach in Stroke (CARAS) that therapists can use to structure and implement treatment of arm-hand function and arm-hand skill performance in stroke survivors based on (a) level of arm-hand impairment, (b) detailed training descriptions, (c) principles of self-efficacy, and (d) swift implementation of interventions.

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A. Level of Arm-Hand Impairment

The CARAS encompasses three modular, group-based training programs divided into two parts, namely taking care and prevention (Part 1) and high-intensity, task-oriented arm-hand performance training (Part 2; see Figure 1). Based on the Utrecht Arm/Hand Test (UAT) scores (Kruitwagen-van Reenen, Post, Mulder-Bouwens, & Visser-Meily, 2009), patients enroll in one of the training programs, each of which consists of well-described and time-delimited building blocks.

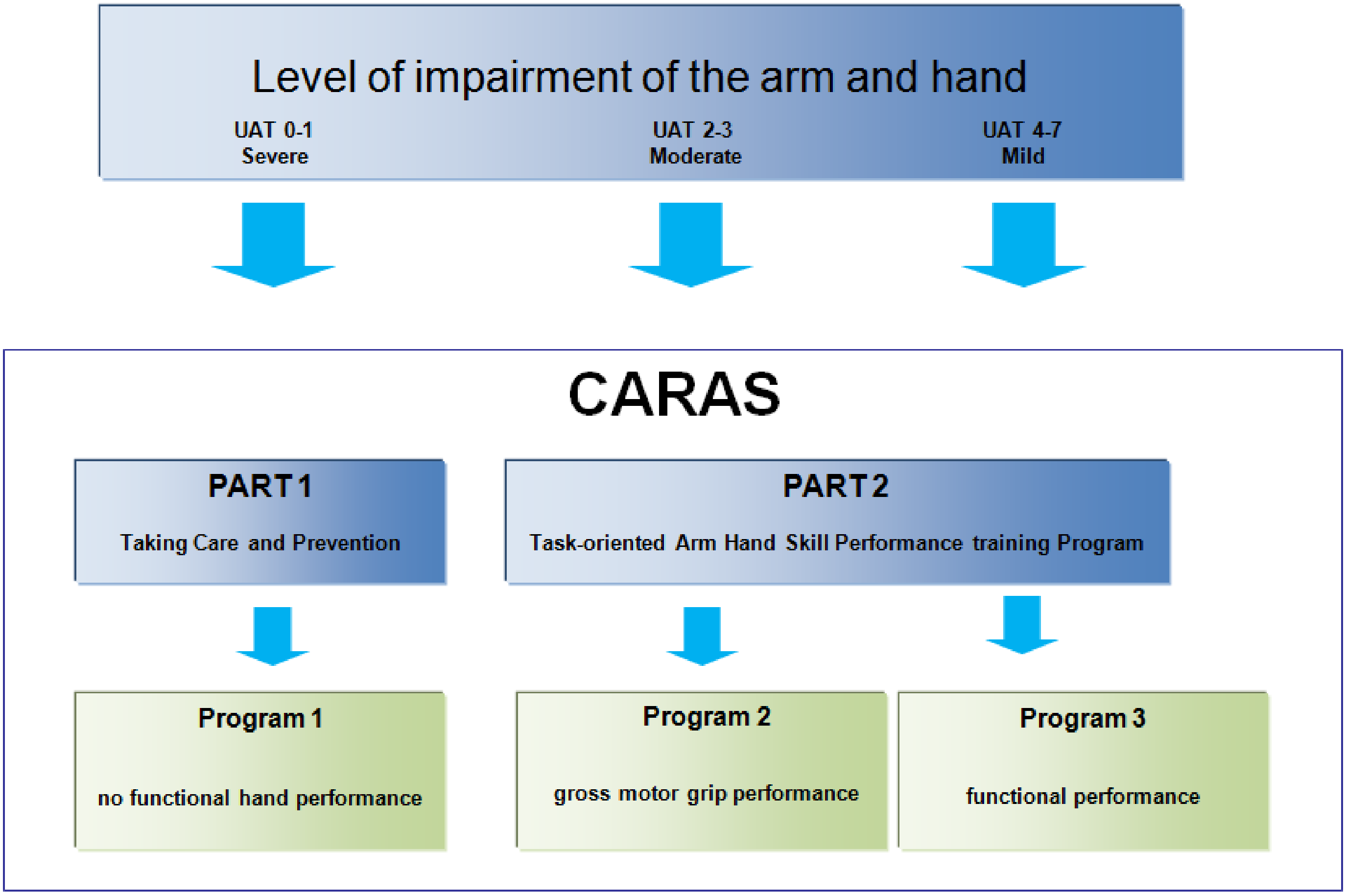

Figure 1. Schematic representation of the CARAS and its constituent programs. UAT = Utrecht Arm/Hand Test (Kruitwagen-van Reenen et al., 2009).

Part 1, encompassing Program 1, is designed for stroke survivors who, due to the severity of the stroke, are not able to use their affected arm-hand for skill performance in daily life situations (non-functional arm-hand) because of inactivity, spasticity, and/or stiffness. Eventually, this disuse can lead to secondary complications, such as pain, problems in performing basic activities of daily living, and hygienic issues (Albert & Kesselring, 2012; Warlow, Sudlow, Dennis, Wardlaw, & Sandercock, 2003). Therapists can manage these complications by coaching patients on how best to care for their impaired arm-hand.

Program 1 targets stroke survivors with a UAT score of 0-1. Interventions are directed toward enabling patients to keep the arm-hand in optimal condition, such as feeling comfortable in various postures both during resting and while performing daily life activities.

Part 2, encompassing Programs 2 and 3, features high-intensity, task-oriented arm-hand training in which patients learn to integrate their affected arm-hand into daily occupations to optimize their overall functional abilities in daily situations. In this part, a distinction is made between patients who have a moderately affected arm-hand (i.e., those who are able to use their affected arm-hand for passive and active stabilization tasks, like holding bread while making a sandwich) and patients who have a mildly affected arm-hand (i.e., those who are able to use their affected arm-hand instantaneously in daily situations).

Program 2 targets stroke survivors with a UAT score of 2-3. These patients have to cope with a moderately impaired arm-hand and are able to use their affected hand to assist the non-paretic arm-hand during bimanual activities in daily life. This program is aimed at gross motor grip tasks, passive and active fixation tasks, grasp and displace tasks, and simple bimanual daily life activities.

Program 3 targets stroke survivors with a UAT score of 4-7. These patients have the potential or are already able to spread the fingers and make isolated finger movements with the affected hand. From the perspective of motor learning, this allows them to use their arm-hand in functional tasks in daily life situations immediately from the start of rehabilitation. This program is aimed at grasp and displace tasks, manipulation tasks, and complex bimanual activities.

B. Training Interventions

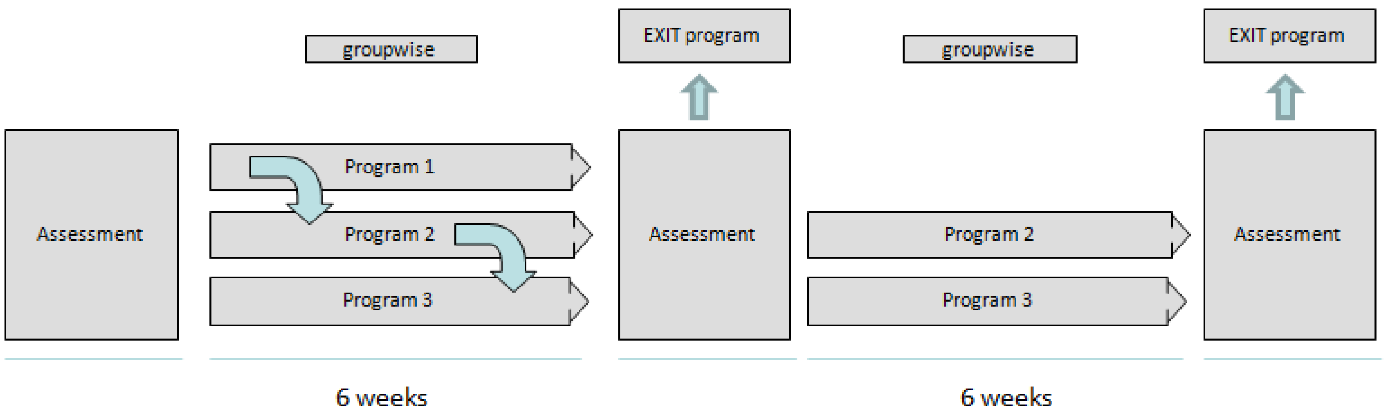

Figure 2. Time schedule of the CARAS.

In order to manage the CARAS' group-based interventions adequately, groups should be limited to six patients. After establishing a baseline via an assessment, patients enroll in one of the three programs and start training for 6 consecutive weeks, followed by a second assessment. Progress is expressed in terms of functional goals reached, based on measures gauging performance levels (e.g., Abilhand) and capacity levels (e.g., the Action-Research-Arm Test [Lyle, 1981] or the Brunstrom-Fugl-Meyer Test [Fugl-Meyer, Jaasko, Leyman, Olsson, & Steglind 1975]). Depending on these results, it is possible for the patient to choose a second 6-week period of training. Furthermore, depending on the progress made, a patient can switch from Program 1 to Program 2 when he or she has regained dexterity in the affected arm-hand (improving from a UAT 1 to 2) or from Program 2 to Program 3 when he or she shows an increase in selectivity in the affected hand, resulting in isolated wrist and/or finger movements (improving from a UAT 3 to 4). This second 6-week period is followed by a third assessment.

B1. Training patients with a severely affected arm-hand. The initial level of paresis is generally regarded as the most important predictor for motor recovery (Nijland et al., 2010). When neurophysiological recovery is absent, patients may be left with a non-functional arm-hand that cannot be used in daily activities. It is not useful to train patients in Program 1 under the same practice conditions and as intensively as patients in Programs 2 and 3.

Patients in Program 1 spend about 4.5 hr a week on training. The training consists of the following topics: Education about the basic principles of how the affected arm is related to the body and mind, and why it is not moving adequately; education and exercises on how to position the arm-hand in different circumstances and postures (e.g., lying in bed or in sport or vocational situations); exercises to avoid discomfort, maintain joint mobility, and maintain muscles/tendons in an optimal condition; exercises to provoke voluntary movement where possible; learning strategies on what to do when discomfort nevertheless arises; and training in the use of supportive tools like static or dynamic splints, braces, and/or slings. Every day during the 5 days per week, one of these topics will be discussed in a group.

A substantial proportion of patients with a severely affected arm-hand will not regain dexterity. The difficulty patients have in dealing with this poor prognosis in the poststroke subacute phase may complicate their treatment and deter adherence. Diminished therapy adherence will hinder the learning process. Therapists may improve adherence by helping the patient to understand his or her reactions and constraints to learned skills, having the patient adopt similar strategies used by fellow patients to cope with their severely affected arm-hand, and providing a valid prognosis based on the patient's individual characteristics. Program 1 is based on the Attitude-Social Influence Self-Efficacy (ASE) model (de Vries, Dijkstra, & Kulman, 1988), which assumes that attitudes, social influences, and self-efficacy expectations determine intention and behavior. These cognitive aspects are coupled with relevant topics for patients with a severely affected arm-hand.

B2. Training patients with a moderately or mildly affected arm-hand. Patients following the task-oriented arm-hand performance training receive intensive exercise training spread across 5 days per week for approximately 7 hr per week. In contrast to Program 1, Programs 2 and 3 provide patients with more training because they are generally able to work more intensively due to the functional capabilities of their affected hand and their overall better condition. In general, the recommended duration of arm-hand treatment is about 1 hr per session (Duncan et al., 2003; Kwakkel et al., 2004; Pang et al., 2006). With respect to the general duration and the frequency of training, phases of 6 to 12 weeks are advocated (Baechle & Earle, 2008; Kisner & Colby, 2007). Given the program's modularity, all of the interventions are embedded in 60 min time blocks, during which the patient starts with the set-up of the training of a personal goal for at least 5 min, followed by 40-50 min of training exercises related to the personal goal. Immediately after this training session, the patient works for at least 5 min toward the same personal goal again. An example of a personal goal may be to handle the garden hose to water the plants.

Programs 2 and 3 target patients with, respectively, a UAT score of 2-3 and a UAT score of 4-7. Patients from both of these groups are eligible for task-oriented training. This involves training in functional (skill-related) tasks with a high level of repetition, assuming an interaction between the task or skill, the patient performing the task, and the context in which the task is performed (Shumway-Cook & Woollacott, 2007; Timmermans, Seelen, Willman, Bakx, et al., 2009). Scientific evidence of task-oriented training being associated with neuroplastic changes is increasing (Jang et al., 2003; Richards, Hanson, Wellborn, & Sethi, 2008), although the variety of training content, combined with different durations and intensities reported, makes it hard to compare treatment effects among interventions (French et al., 2008). Clinical management of motor control problems in task-oriented training uses the following five steps:

1. Perform a task analysis together with the patient and quantify functional abilities.
2. Check the strategies used to accomplish functional skills.
3. Consider which underlying sensory, motor, or cognitive factors constrain functional movement and which factors might be the most trainable.
4. Choose a suitable motor learning approach and appropriate practice conditions.
5. Train as functionally as possible to accomplish well-defined results based on successful transfer of the learned task from a clinical environment to the home environment (Shumway-Cook & Woollacott, 2007).

The application of these five steps in arm-hand rehabilitation practice is outlined below.

Step 1: Task analysis. In the first week of Programs 2 and 3, the therapist establishes the level of task performance by asking the patient to perform a meaningful and attainable functional task. The focus is on whether the patient can do the task and the degree of difficulty. The therapist determines the degree to which the patient uses the affected arm-hand during the task.

Step 2: Strategies used to accomplish functional skills. During the execution of the task, the therapist analyzes the task performance strategies used by the patient. After examining the patient's problem-solving strategy, small adaptations to the task may be made. In these situations, the therapist examines the underlying mental and physical capacities of the patient; the mental, cognitive, and motor demands of the task; the strategies used by the patient to meet these demands; and the patient's ability to choose the most efficient strategy for a given task (Shumway-Cook & Woollacott, 2007).

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Step 3: Constellation of impairments. The multitude of underlying cognitive and/or sensory-motor deficits that contribute to the ability to use the affected arm-hand in real life activities are determined by using the Action Model of Goal-Directed Movement (Smits-Engelsman, Galen, & Hulstijn, 1997). Subsequently, the Hypothesis-Oriented Clinical Practice method (Arocha, Patel, & Patel, 1993; Elstein, Shulman, & Sprafka, 1978) is used to establish an adequate starting point for the interventions. Specific exercises for the patient will be set up in the first week in accordance with the patient's individual needs and the existing capabilities of the paretic arm-hand.

Step 4: Practical applications of motor learning. Based on the outcome of the first three steps, a suitable learning approach and concomitant practice conditions are chosen, taking into account that (a) the practice focuses on the execution of functional tasks (Van Peppen et al., 2004); (b) in most cases, retraining motor skills demands large amounts of practice and a great deal of time spent on arm-hand therapy (Kwakkel, Wagenaar, Koelman, Lankhorst, & Koetsier, 1997; Kwakkel, Wagenaar, Twisk, Lankhorst, & Koetsier, 1999); and (c) the training starts in an early phase of rehabilitation, thereby avoiding learned nonuse and the development of abnormal movement patterns as well as preventing secondary symptoms (Langhorne et al., 2011; Rodgers et al., 2003).

Step 5: Transfer to real life performance. Transferring the goals set during the period of training both to a new task and to the patient's situation is vital and strongly influences treatment success. Facilitating transfer is done by setting goals that are meaningful and feasible from the patient's perspective. In addition, there must be a need to execute these goal-related tasks regularly. This is done by setting up practice conditions that closely resemble the demands of the patient's personal situations in his or her daily environment. To further enhance these practice conditions, patients are encouraged to bring their own materials and instruments to the program. Homework assignments are listed and distributed on Fridays, before the patients go on weekend leave, and evaluated the next Monday, thus providing new insights into the operational capabilities of the affected arm-hand in home situations.

In Programs 2 and 3, the effects of task-specific training may generalize toward other, untrained tasks (Schaefer, Patterson, & Lang, 2013). A way to support this generalization is to stimulate the patient's awareness of the operational capability of the affected hand in a positive way in order to increase spontaneous use of this hand in an early phase of rehabilitation (Taub, Uswatte, Mark, & Morris, 2006). To do this, patients are offered and employ a broad variety of frequently used and familiar tasks that they face in daily practice in their home environment and, in most cases, also during their rehabilitation period. For this purpose, six intervention modules have been developed. Each module contains a selection of tasks specifically addressing personal goals (see Figure 3).

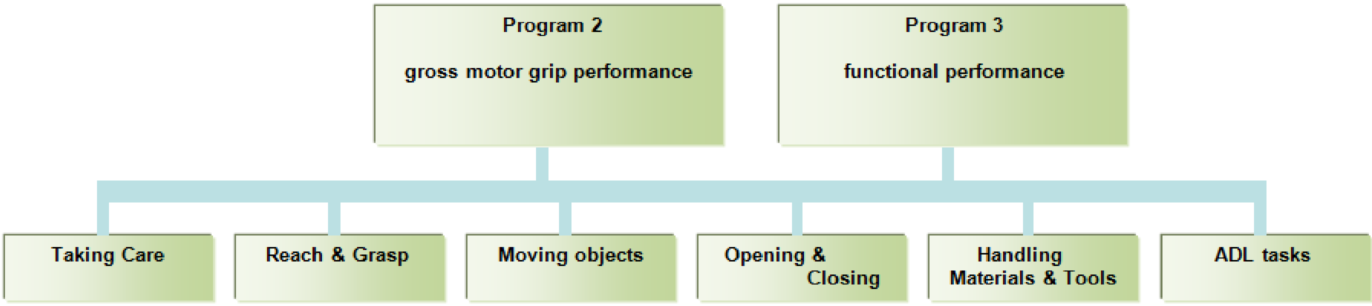

Figure 3. Six training modules used in Programs 2 and 3 of the CARAS.

The first module (taking care and prevention) focuses on improving and maintaining an optimal condition of the paretic arm-hand. Compared to the version in Program 1, this module contains different exercises aimed at getting and keeping the affected shoulder and arm-hand supple and free of pain, which is also relevant for patients with a higher functional arm-hand. The other five modules are aimed at improving arm-hand skills performance, targeting reach and grasp tasks, moving objects, opening and closing items (e.g., a door, drawer, zipper, buttons), handling materials and hand-operated tools (e.g., screwdrivers or a hairdryer), and completing activities of daily living (e.g., using a towel or a toothbrush). The tasks are grouped into three levels of difficulty (easy, medium, and hard) and are based on the stages described in the Brunstrom Fugl-Meyer Test (Fugl-Meyer et al., 1975).

C. Self-Efficacy

A contemporary method for improving patients' ability levels is promoting their self-efficacy. Self-efficacy is described as confidence in one's ability to perform a task or exert a specific behavior (Bandura, 1994). Many interventions that enhance self-efficacy may elicit positive effects on peoples' outcome after stroke (Jones, 2006; Jones & Riazi, 2010; Korpershoek, van der Bijl, & Hafsteinsdóttir, 2011) as applied in task-oriented training methods (Salbach et al., 2005) or group education interventions (Kendall et al., 2007). Therapists can incorporate principles of self-efficacy for improving patients' empowerment. By extracting and defining goals, patients are enabled to work toward their goals, boosting their belief in improvement. This may result in patients integrating their affected hand in daily activities. The self-efficacy principles, explained below, are essential to the success of Part 2 of the CARAS and should be integrated in daily routine practice.

1. Mastery experiences*:* positive experiences with a task/skill.
2. Vicarious experience: comparison of oneself to other patients.
3. Verbal persuasion: encouragement of the patient during exercising.
4. Physiological feedback: beliefs formed from feedback produced by the patient's own physiologic state (Bandura, 1997).

Mastery experience. The development of efficacy beliefs through enactive experience creates effective performance (Bandura, 1997).

Therefore, therapists should strive to create patient involvement and motivation during the therapy programs (Locke & Latham, 2002; Sivaraman Nair, 2003). Prior to the training program, a semi-structured interview is performed to extract three to six activities that are both meaningful and challenging to that patient. The important characteristics of these activities are that they have to be used frequently and be directly related to home-based activities in daily life. These activities are converted into attainable and meaningful goals and are rated by the patient on a six-point ordinal (Likert) scale varying from *very easy to perform* to *very difficult to perform*.

Complex skills are often broken down into subskills that are easier to master. These subskills (part practice) are subsequently presented in a chronologic sequence to acquire or recover the complex skill (whole practice; Bandura, 1997). Progression toward each goal is monitored in a personal training diary, rated by the patient three times a week using a quantitative measure, such as a visual analogue scale or the time used to perform the goal. At the end of each week, progression in goal-attainment is visualized graphically. Identifying even small steps made toward the goals is done by patients themselves to stimulate confidence and to maintain a positive trend regarding their self-perceived ability level (van de Laar & van der Bijl, 2001). After six weeks, all goals are re-evaluated and rated using a 6-point Likert scale.

Vicarious experience. Observational practice can make unique and important contributions to learning, especially when the observation is combined with physical practice (Shebilske, Regian, Arthur, & Jordan, 1992). In the CARAS' Programs 2 and 3, the patient works toward his or her individual goals in groups of patients who experience similar motor impairments. Each individual is able to observe the others while exercising. Working on an identical activity level facilitates learning through mutual observation and reduces insecurity through role modeling and dyad practices (Shea, Wright, Wulf, & Whitacre, 2000). Another way to provide vicarious experiences is to have the patient observe himself or herself as a model using video recordings taken during different time epochs during one or more sessions.

To obtain persuasive model conditions, it is important to create certain similarities in the training sessions (e.g., two patients who have a similar goal, like eating with a knife and fork). The third method of providing vicarious experiences is to use the therapist as a role model, especially in situations that warrant giving extrinsic feedback as a way to increase knowledge of performance (Shumway-Cook & Woollacott, 2007).

Verbal persuasion. Feedback that emphasizes successful performance and ignores less successful attempts benefits learning and may boost motivation (Bandura, 1997). During training, small progressions can be noticed and conveyed as positive feedback to the patient. Patients are also taught to identify these small progressions and to provide positive feedback to themselves and, when possible, to fellow patients. Positive family and social support may improve motivation and functional recovery (Tsouna-Hadjis, Vemmos, Zakopoulos, &

Stamatelopoulos, 2000). The CARAS encourages family to visit sessions. Furthermore, homework assignments are provided so that in home-based situations during the weekends the family can notice and encourage skills mastered by the patient.

Physiological feedback. Somatotopic maps (i.e., body schemes) are not rigid but are subject to constant modification, depending on experience, and are updated during movement (Haggard & Wolpert, 2005). Besides the loss of voluntary movement in the affected arm-hand, in the first weeks poststroke the loss of touch detection and proprioception has been noted in a high proportion of patients (Carey, 1995). During this phase, patients often cope with a changed perception of the affected arm-hand (Longo, Azañón, & Haggard, 2010), which influences their own judgment on the functional capability of the arm-hand. Enhancing patients' confidence in performing tasks can be achieved by adjusting perceptions (DeSouza, 1983). Maintaining or improving these perceptions is done by: (a) explaining (physiological) mechanisms underlying symptoms, such as co-contraction, lack of proprioception, and/or voluntary movements, experienced by the patient during skill performance; (b) providing interventions in situ fitted to the most relevant problem (e.g., providing additional muscle strength training during a functional task training like cutting meat); and (c) relating progressions made to relevant tasks.

D. The Swift Implementation of Interventions

In order to keep up with the state-of-the-art evidence and to test new developments, the CARAS can be easily adapted without having to resort to major (systemic) alterations, like the time of treatment or the (chronological) content of treatment.

The CARAS consists of time blocks in which the type of training is defined. Other blocks with different content can easily replace parts of these blocks and their content. However, starting with setting personal goals and evaluating these goals again after a period of training should be maintained. Working in time blocks makes it easier to respond quickly to new developments, like the use of aids. Removing a single training component and replacing it with another component provides valuable insight into the added value of that component. Therapists can evaluate the effectiveness of the newly implemented component by using the assessments on performance level and capacity level (presented in Section B), and the quantitative self-evaluation method (outlined in Section C).

Discussion

The aim of this paper was to present a modular and clinically manageable arm-hand rehabilitation framework (the CARAS) that therapists can use to structure and implement their treatment of arm-hand function and arm-hand skill performance problems in stroke survivors. The authors tackle four common problems that therapists face during the rehabilitation of stroke: the heterogeneity in dexterity of the affected arm-hand, the lack of the patient's engagement with therapy, the nontransparency of procedures, and the slow response to innovations (Kuipers & McKenna, 2009; Langhorne et al., 2011; McDonnell et al., 2013; Oujamaa, Relave, Froger, Mottet, & Pelissier, 2009). To provide answers to these problems, self-efficacy principles and task-oriented training methods have been merged into a modular program, stratified for level of arm-hand impairment, and designed to be easily adaptable in response to innovations.

The CARAS induces at least three changes in the rehabilitation of stroke survivors. First, different patterns of recovery of upper limb function imply that individual patients will have different rehabilitation needs (Meldrum et al., 2004). With respect to the heterogeneity among these recovery patterns, the use of dexterity levels (based on UAT scores) is helpful for therapists to target specific motor problems related to the paretic arm-hand (Langhorne et al., 2011). Stratification, based on the presence of dexterity and corresponding functional possibilities, facilitates a better focus and tailored therapy delivery.

Second, to create an optimal state of readiness in patients, self-efficacy principles are embedded in the CARAS. The effectiveness of self-efficacy principles, however, is not clear (Boger, Demain, & Latter, 2013). In line with several other studies (Dixon, Thornton, & Young, 2007; Kendall et al., 2007), four sources of self-efficacy are applied in the three programs constituting the CARAS. However, when adapting these sources of self-efficacy during training, it is vital to keep in mind that some patients may not be able to understand all aspects of self-efficacy. As a result of their stroke, patients may experience cognitive and/or mood disorders. Mood states can bias attention and can affect how events are interpreted, cognitively organized, and retrieved from memory (Bower, 1983; Eich, 1995). Cognitive disorders are a major exclusion criterion for most studies that examine self-efficacy or self-management interventions (Boger et al., 2013). The CARAS includes patients with cognitive disorders. Mastery experiences are the most important sources of efficacy information because successes build a robust belief in one's personal efficacy (Bandura, 1994). Therefore, this source is used constantly, independent of problems perceived and exercises performed. The other three sources—vicarious experience, verbal persuasion, and physiological feedback—are used more intermittently, depending on the patient's cognitive status and mood status.

Third, the task-oriented training method combined with the self-efficacy principles used in Part 2 of the CARAS lead to a condensed organizational structure that resolves several logistical issues. Patients commit themselves to be present during a minimum of three sessions weekly for six consecutive weeks and, in line with task-oriented training, a minimum of 40-50 min of training should be provided during each session. The CARAS' modular structure, coupled with its clear timing and concomitant assessments, provides the patient, his or her family or partner, and the therapist with valuable insight into any progress made, the prognosis of the impaired arm-hand, and additional therapy requirements.

Finally, following the implementation criteria for using technology in rehabilitation (Hochstenbach-Waelen & Seelen, 2012) facilitates the use of technology in the CARAS. Its modular structure allows for quick implementation of new interventions. Stratification of patients into three groups (severely, moderately, and mildly impaired) makes it easier to match quickly new technologies to patients' needs (Brewer, McDowell, & Worthen-Chaudhari, 2007). The added value of new technologies may be evaluated in the clinical setting by using standard, objective measures in the assessment phases.

There is a variety of existing arm-hand programs, each tackling one or more of the aforementioned problems. For example, the ICARE protocol (Winstein et al., 2013) and the task-specific training method of Arya et al. (2012) both provide a structured framework and customized therapy with challenging activities related to the real-world tasks chosen by the patient. The amount of training time in the BATRAC bilateral arm training (van Delden, Peper, Beek, & Kwakkel, 2011) shows similarities with the training intensity of the CARAS' Programs 2 and 3. The upper extremity treatment program of Wallace et al. (2010) contains training blocks and a stratification of patients with a mildly affected arm-hand into three levels, thereby accommodating graded functional training. McDonnell et al. (2013) incorporated a hypothetico-deductive framework in their arm-hand program. To our knowledge, however, there is no program that targets all four problems and their concomitant solutions as presented above. The CARAS merges experience-based clinical treatment with evidence-based interventions, targeting clearly defined populations and covering a substantial part of the stroke population with an affected arm-hand. Its theoretical framework makes it easier to identify clear targets or goals toward which the patients can train. The CARAS provides a systematic approach to therapy and accommodates appropriate evaluation methods for evaluating novel developments to be implemented.

Considerations

Some considerations regarding this framework should be mentioned. Although the initial results relating to progressions made during and after therapy are hopeful, the added value of the CARAS compared to other existing arm-hand programs has not yet been evaluated. It has, however, been successfully implemented at Adelante Rehabilitation Centre.

The second limitation is that the program requires a certain number of therapy hours for six consecutive weeks. This six-week schedule demands regular timing in a patient's therapy schedule, which may sometimes conflict with other therapy related to stroke rehabilitation in the subacute phase.

Future Research

Future research will focus on (a) evaluating the outcomes of the CARAS and comparing it to other arm-hand treatment programs in stroke, (b) implementing the program in additional centers, and (c) further optimizing the CARAS regarding the dose-response relationship and the number of hours involved in face-to-face therapy delivery.

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