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What are the "ingredients" of modified constraint-induced therapy? An evidence-based review, recipe, and recommendations

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Abstract. Modified constraint induced movement therapy (mCIT) increases paretic upper extremity use and movement in all phases of stroke. Although fundamental to its appropriate implementation, specific details on day to day implementation on this promising family of therapies have not heretofore been published. Consequently, some integral behavioral facets of mCIT may be overlooked, while other approaches may be easily mistaken to constitute mCIT, during attempts to implement the therapy. The purpose of this paper is to review mCIT, and to provide the clinician-reader with a detailed description of the "ingredients" of mCIT and their rationale, including clinical examples of these components. It is expected that a more complete understanding of the components comprising this promising approach will overcome knowledge barriers associated with its appropriate use, and encourage better patient management in clinical practice.

Keywords: Rehabilitation, stroke, occupational therapy, physical therapy, hemiplegia

While advances have occurred in acute stroke management, few patients actually receive many of the promising approaches that have been developed (Kleindorfer et al., 2004). Additionally, most stroke risk factors are becoming more prevalent (e.g., diabetes; tobacco use; overweight/obesity) e.g., (Narayan et al., 2006). The above developments, when combined with an increasingly aged population, are expected to produce a stable stroke incidence – and a larger prevalence of impaired stroke survivors – during the next decade (Broderick, 2004).

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Given these trends, there is a need for efficacious rehabilitative treatments for stroke-induced impairments, including upper extremity (UE) hemiparesis. Recently, increased paretic UE use and function were reported after patients participated in constraint-induced movement therapy (CIT) (Wolf et al., 1989; Taub et al., 1993; Miltner et al., 1999; van der Lee et al., 1999), during which: (1) patients' non-paretic UE's were restricted during 90% of waking hours of a 2-week period; and (2) patients engaged in 6-hour activity sessions using their paretic UE's on 10 weekdays of the same 2-week period. Yet, while CIT appears efficacious, a survey (Page et al., 2002a) reported that some patients may not wish to participate in CIT, that >80% of therapists felt that patients were extremely unlikely to adhere to CIT, and that many facilities did not have resources to execute CIT. Other CIT studies have reported an attrition rate of 32% (Schaumburg et al., 1999), poor compliance with the CIT restrictive device wear (Page et al., 2002a; Ploughman and Corbett, 2004; Blanton and Wolf, 1999), and that subjects are only capable of participating in about 3.95 hours of the six-hour CIT clinical regimen, mostly due to fatigue (Kaplon et al., 2007). Thus, there remains a need for efficacious interventions that reduce UE hemiparesis within the confines of real-world clinical and payer restrictions.

1. Modified constraint-induced therapy

Given the above CIT shortfalls, several groups have examined alternative CIT delivery methods, with a primary focus on distributing the home and clinical practice schedules over longer time periods. One of the results of this work was modified constraint-induced therapy (mCIT): an outpatient protocol combining structured, 1/2-hour, functional practice sessions using the paretic UE with restriction of the non-paretic UE 5 days/week for 5 hours, both during a 10-week period. mCIT increases paretic UE use and function in the days (Page et al., 2005), months (Page et al., 2002b, 2001, 2002c), and years (Page et al., 2004, 2008) after stroke, as well as traumatic brain injury[1] (Page and Levine, 2003). The positive motor changes associated with mCIT participation are retained – and, in some cases, continue to increase – months after the therapy is administered (Page et al., 2011). A recent meta-analysis also reported that the CIT and mCIT treatment effects are comparable to each other on functional outcome measures of arm impairment and function (Hakkennes and Keating, 2005), confirming that “ . . . any technique that induces a patient to use an affected limb . . . should be considered therapeutically efficacious . . . ” (Taub et al., 1999) p. 243. Moreover, the changes in amount of affected arm use associated with mCIT have been larger than those observed with CIT. For example, Dettmers and colleagues (Dettmers et al., 2005) reported a 1.9-point amount of use change on the Motor Activity Log. Likewise, the average amount of use score change from Pre to Post reported by Miltner and colleagues (Miltner et al., 1999) was 1.42 points. The amount of use change in the Page et al study (Page et al., 2004) (ref 17) – which enrolled the same population as these studies – was 2.38 points. We have speculated elsewhere that this is likely due to the fact that the mCT protocol provides nearly two times as many paretic arm use opportunities over its 10-week period than the CIT protocol does during its 2-week period, leading to greater operant re-conditioning of use of this arm. Other data suggest that cortical reorganizations, are associated with the UE use and motor changes seen after mCIT participation (Szaflarski et al., 2006). To date these findings have only been reported in a small sample of individuals with chronic stroke; however it is likely that a multitude of techniques encouraging repeated, functiuonal UE use have these same effects (Taub et al., 1999), p. 243. The promise of protocols using distributed practice schedules such as mCIT has also been supported by decades of learning research (Bourne and Archer, 1956; Baddeley and Longman, 1978; Wright and Sabin, 2007; Ofen-Noy et al., 2003) with such protocols believed to positively affect motor memory consolidation (McGaugh, 2000). Like the opportunity for more operant conditioning, the use of a distributed practice schedule and greater motor memory consolidation is likely to undergird the larger affected arm use changes that have been observed when mCIT has been used.

1.1. Making soup or just boiling water? The current paper

Because of its efficacy and presumed straightforward clinical application, we often encounter therapists attempting to implement mCIT. However, we find that many of these individuals mistake forced use of the paretic UE for mCIT (see reference (Gordon et al., 2005) for a discussion), and/or they overlook inclusion of the behavioral strategies that differentiate mCIT from other rehabilitative regimens. For example, a local therapy manger insisted that her facility was implementing mCIT by giving stroke patients written forms in combination with “tying up the good limb.” Another therapist at a local “stroke recovery center” shared patient informational sheets with us, which were proported to act as surrogates for the important behavioral strategies that are part of mCIT.

In many ways, we liken mCIT provision to the process of making soup: the inclusion of certain ingredients by the chef (i.e., the therapist) are an absolute necessity in making a delicious soup, whereas inclusion of other ingredients may be somewhat desirable

[1]It is worth noting that the therapy is also currently being tested in multiple sclerosis and cerebral palsy.

when they are available, may be optional, could be substituted with other ingredients, and/or may only nominally add to the taste of the final product. Still other ingredients may be suggested by the chef, but actually be nonessential, or their inclusion may make the soup inedible. In the same way, there are some mCIT "ingredients" that are evidence-based and fundamental to successful mCIT provision, there are some that are optional, and some that, when used, are not at all consistent with the principles of this family of therapies. We recognize that differentiating which of the available "ingredients" are the most important to efficacious mCIT administration may be difficult. The genesis of specialized CIT seminars that are fiscally and temporally difficult for many therapists to attend, the relative paucity of "day to day details" on its practical implementation in published clinical trials, and the publishing of many of the major CIT and mCIT trials in journals that therapists do not habitually read are but a few of the challenges that may hinder its appropriate implementation. Given these obstacles and the unique qualities of mCIT, the purpose of this paper is to identify the "ingredients" of mCIT for clinical implementation. Specifically, this paper endeavors to define and describe the various facets that constitute mCIT, and to provide examples of how these "ingredients" are applied in typical clinical scenarios.

When developed over a decade ago, mCIT was the first therapy devised to overcome challenges associated with the practical clinical implementation of CIT. Since appearing in those "first in class" papers, the term "modified constraint-induced therapy" and its abbreviation (mCIT) have consistently referred to a specific, 10-week, protocol as described herein. Nonetheless, the term "modified constraint-induced therapy" and its abbreviation have recently been attributed to any protocol in which the parameters of CIT were modulated e.g., (Earley et al., 2010; Aarts et al., 2011; Leung et al., 2009). Such work can create confusion, since later authors are claiming to test mCIT, yet their treatment regimens are entirely different than the original mCIT work (Kaplon et al., 2007; Page et al., 2005, 2002b, 2001, 2002c, 2004, 2008; Page and Levine, 2003) in at least two key ways: (a) their protocols do not match the 10-week mCIT duration parameters that were developed to overcome the intensive CIT limitations; and/or (b) the protocols do not contain many of the behavioral elements that differentiate mCIT from other treatment regimens. It is hoped that this paper will clarify define the facets that constitute mCIT as originally and consistently described in the literature over the past decade. While this paper concentrates on our experiences with mCIT, it is plausible that some facets described herein may also apply to CIT.

2. Breaking down the mCIT "Recipe"

2.1. *Motor training of the paretic UE: Repetitive task specific training*

Many paretic rehabilitative strategies are proported to reduce UE hemiparesis, with several of these still taught in seminars and educational programs around the world. While a review of each strategy is beyond the scope of this paper, it is worth noting that some of the commonly-used approaches to UE hemiparesis have a negligible or negative impact on UE hemiparesis (de Pedro-Cuesta et al., 1992; Duncan, 1997; Barreca et al., 2003), and/or have not rendered as large a treatment effect as CIT or mCIT in prospective clinical trials (Miltner et al., 1999). As described elsewhere (Salbach et al., 2007), the continued use of less efficacious strategies in the treatment of UE hemiparesis often has to do with the training and knowledge of the therapist with these techniques (as opposed to "newer" techniques), the comfort of the therapist in accessing and/or translating more "new" techniques to clinical practice, and/or organizational barriers to accessing and implementing the most recent evidence.

Despite others' continued use of such approaches, repetitive task specific training (RTP) has been the basis for motor training of the paretic UE in our mCIT efforts. We chose this approach because: (a) there is widespread support for the use of RTP as a fundamental basis for retraining UE function e.g., (Mulder et al., 2002; Woldag and Hummelsheim, 2002); and (b) recent studies suggest that motor learning-based RTP strategies are frequently used by therapists in the weeks and months after stroke (Jette et al., 2005; Latham et al., 2006). Thus, we felt that the integration of mCIT into regular clinical care was likely to be more seamless if mCIT incorporated a proven therapeutic strategy that was already used by many therapists.

Prior to the beginning of the ten week intervention period, each patient will have selected 3 to 5 tasks that he/she wishes to relearn, usually with the assistance of his/her therapist (and, possibly, his/her care partner). The purpose of incorporating others into the goal setting process is to assure that the selected goals are appropriate and realistic. Tasks are also selected on the basis of challenge, so that the patient will not simply complete activities because of apparent ease. Including challenge as a facet of the task selection process is intended to maintain patient interest, and because the notion of challenging the patient appears to be a major factor in facilitating cortical plasticity (see Kleim et al., 2002).

It is surprisingly difficult for some patients to identify appropriate, motivating, and challenging tasks that they wish to relearn with the paretic UE. Thus, our team uses many tools to assist patients in selecting tasks, including: (a) The Canadian Occupational Performance Measure (COPM) (Law et al., 2000), an interview-based outcome measure that helps patients to pinpoint tasks that are important to them, the relative importance of each task, and occupational performance problems associated with each task. Specifically, after identifying tasks of importance in several domains, patients rate on a scale from 0–10 the importance of each task to them, their perception of their performance with skills, and satisfaction with how well they perform each of the movements. Once the top five activities are determined, these tasks are used to guide the treatment. (b) The Motor Activity Log (MAL) (Taub et al., 1993), which is a semi-structured interview measuring how much and how well patients use their paretic UE's for home and community-based activities. Both patients and care partners (when possible) use a 6-point Amount of Use (AOU) scale to rate how much the patients are using the UE, and a 6-point Quality of Movement (QOM) scale to rate how well they are using it. Previous research indicates that the MAL is a valid and reliable scale of arm use and movement quality in real world settings (van der Lee et al., 2004). (c) Patients may also choose movement goals from a battery of about 80 commonly-enjoyed activities of daily living (ADLs) that are age and impairment level-appropriate. This list was culled together over our years of administering mCIT and other stroke rehabilitative therapies that emphasize repetitive UE use. (d) Occasionally, patients are also able to self-identify appropriately challenging and motivating tasks.

The 30-minute, clinical, RTP sessions are administered three days per week during a ten-week period. Upon selecting tasks, activity analysis (see ref (Hersch et al., 2005) for a review) is used to "break down" each selected task into smaller movement components that require successful completion before the entire task is "put back together". For example, if the patient enjoys potting and planting, the first component would be reaching to grasp and release a hand shovel. Then raising the shovel to the top of a pail and placing it back on the table would be reinforced through RTP. Ultimately, the entire complement of movements including shoveling dirt into the pot and placing seedlings or plant stems would be accomplished. As can be deduced, this sequence places progressive greater demands on multi-joint control and sequencing. Spatial control would be accomplished through progressively moving the object further from the participant, thus imposing greater ranges of joint motion. Ultimately, the participant would be undertaking activities in a standing position, thus imposing postural control and weight shifting demands as well. Temporal domain elements would be engaged by requiring the patient to repeat the task components or total task activity as frequently as possible during a defined time interval. In this way, motor learning of the complete task, via organized, repetitive practice of its smaller components and eventual assimilation of the components, is realized.

While we have regularly used RTP as a basis for motor training during mCIT, it is worth noting that we occasionally integrate facets of other therapeutic approaches to augment RTP during the 30-minute clinical sessions. For example, as a patient becomes more advanced in a reaching movement, we have placed a hand on the patient's shoulder or even a Velcro strap across the chest to isolate paretic shoulder flexion, paretic elbow extension, and paretic wrist extension, while discouraging compensatory movements with the torso. Likewise, we have occasionally administered targeted, cyclic, electrical stimulation or stretching to specific muscles to facilitate more active patient participation during ADL attempts. The decision to include such strategies is made on a case by case basis, and should not be mistaken as a suggestion to replace RTP entirely with other regimens. Restated, we consider RTP to be an essential "ingredient" that is fundamental to successful mCIT implementation.

2.1.1. Shaping during RTP

We have sometimes encountered therapists who incorrectly assert that combining RTP (or other rehabilitative strategies) with constraint of the non-paretic UE – but without the accompanying use of behavioral strategies – constitutes "modified constraint-induced therapy." A distinguishing facet of the RTP that is part of mCIT is the integration of shaping during the RTP sessions. "Shaping" is a conditioning procedure during which an existing behavior is gradually, iteratively changed across successive trials to a different behavior (Skinner, 1938). The use of this technique is based on CIT work and is described elsewhere as related to CIT (Taub et al., 1994). Within the context of mCIT, the primary goal of incorporating shaping strategies is not necessarily improved movement (although that is often a by-product of its use). Rather, the goal is to increase the amount of UE use (i.e., motor behavior) and, specifically, to make paretic UE use more habitual.

During mCIT, shaping is manifest in several ways that include: (a) the use of carefully-selected tasks, matched to the motor deficits and goals of each patient. Restated, when choosing movement components to be practiced, the goals are structured so that each movement that is practiced is challenging for the patient, yet also attainable (sometimes called a "just-right challenge" in our laboratory); (b) the provision of timely,

Table 1
Examples of reinforcement strategies that are used during shaping with mCIT

Type and when provided	Behavioral definition and intention	Example
Encouragement provided copiously during movement performance	Providing large amounts of positive reward/positive verbal feedback while the patient moves. Intended to encourage gainful attempts of the movements	"Keep on going;" "Reach! Reach!" "C'mon!" Clapping hands; Cheering on the patient during the attempt
Encouragement after movement performance	Providing large amounts of positive reward/sincere positive feedback after each movement attempt. Intended to be a form of shaping the desired behavior	"That was great!" "Good job!" "Wow!" High five with patient. Clap hands for patient
Encouragement inherent in accomplishing the task	Positive encouragement or reward that the patient realizes by successfully performing the task. Intended to facilitate further attempts of the task and/or adding challenge to the task	Patient successfully grasps and drinks out of cup; patient legibly writes name
Performance-related feedback during the movement performance	Providing "real time" information on the movement being attempted; can be spatial, temporal, and be qualitative or quantitative. Intended to facilitate knowledge of performance during the movement attempt	"Can you move your arm (higher, lower over here) (i.e., real time spatial feedback); "A little farther!" "Just a few inches more!" "Faster!" Counting out loud the number of seconds the movement is taking to perform (e.g., "one, two, three, four . . . "). Placing the therapist's hand on the patient's paretic shoulder to prevent compensatory humeral flexion
Performance-related feedback after the movement performance	Providing quantitative or qualitative information directly after the movement attempt. Can be spatial or temporal. Intended to facilitate knowledge of results after the movement attempt, to be used on subsequent movement attempts	Review time taken to perform task with patient (e.g., using a stopwatch); Show patient video captured of movement performance using a laptop camera; Compare the movement just attempted with the same movement a few weeks ago (e.g., show the video of the movement 2 weeks ago versus now). Note that, if the patient is progressing, this example may also constitutes positive encouragement/shaping; Therapist ratings of movement (e.g., using an outcome measure such as the COPM; rating from 1 to 5 how well the patient performs the movement)
Coaching	A form of knowledge of results in that its content is usually based on previous attempts. However, coaching attempts look forward to the next movement, and are intended to provide detailed information or cues on how the patient can improve the attempt on the next try. Coaching is provided copiously, but not as frequently as other strategies discussed above. Coaching attempts may also be a point during which adaptations may be introduced	"Next time you do the movement I would like you to concentrate on . . . " "You did a great job grasping the pen; however, let's try a slightly thicker pen this time and see if that makes it easier. Everything else looked great!"

Note. For more information on the concepts of "knowledge of performance," "knowledge of results," and their importance to motor learning, the reader is encouraged to consult the following reference: Winstein, C.J. (1991). Knowledge of results and motor learning – implications for physical therapy. Phys Ther, *71*(2), 140-149.

Table 2
Example of how shaping might be applied to a commonly-selected task

The task	Patient chose reaching for his favorite coffee mug while seated as one of his tasks. Thus, he was asked to bring the mug into the clinic. A table and chair were chosen that were comparable in height, width, and texture to those at his home
Ways in which the task can be shaped to adjust level of challenge for patient	Distance of cup from patient; Placing obstacles near the cup or in the reaching trajectory that patient has to avoid (e.g., a bowl or plate with food); Using a taller or heavier cup; using a cup with/without a handle; Adding liquid to the cup or adding weight cuffs to patient's arm during reach attempts; Starting position for patient (starting in lap versus starting with hand on table)
Examples of performance-related knowledge of results that could be provided with this task to "shape" its execution	Time required to perform part or all of the movement (e.g., touching the cup versus grasping the cup and bringing it to the mouth then replacing it on the table); Quality of movement as rated by therapist; Quality of movement as shown using video; Number of repetitions within a fixed amount of time; Amount of weight used

frequent, rich feedback after each movement attempt. In our laboratory, we use stopwatches, videotape (in the form of digital files captured via digital cameras), and other forms of feedback to show the patient how the time and/or quality of movement is changing with practice. In this way, this also constitutes an additional form of reinforcement that is likely to encourage paretic UE use. (c) Reinforcement, which refers to providing direct, positive, acknowledgement when achievement of a desired motor behavior occurs. While relatively straightforward, this is possibly one of the least-used but most potent behavioral strategies that can be used (both with mCIT and outside of it). There are many forms of reinforcement (see Table 1), including verbal praise, positive physical expression, concrete rewards, and rewards inherent in completing the activity. Reinforcements should be identified in such a way that they are individualized to be meaningful to the particular patient. We include this in tabular format as this is one of the most straightforward – yet often overlooked – ingredients that can impact the patients' motivation, knowledge of their progress, and motor behavior. (d) Regular, systematic encouragement to perform progressively more difficult components of the desired task, and progression to the next task. As stated above, we deploy a variety of methods (e.g., stopwatches, videotaping, measures of movement accuracy or proficiency) to show the patient how he/she is performing. However, the data collected from these sources also provide the therapist with information about how well the patient is performing, and when the movement should be made more challenging. If a patient performs 10 trials of a particular movement, and is demonstrating the desired level of ease, skill, accuracy, strength, and/or speed on 7 or 8 trials, a new task will be begun, or additional components with greater demands will be layered on to the current movement to make it more difficult (Taub et al., 1994). An example of how shaping might be integrated into RTP of a task is provided in Table 2.

While therapists have asserted to us that they habitually employ shaping as part of their treatment regimens, there are several key distinctions between shaping and conventional rehabilitative training. First, shaping is usually standardized and systematic in the ways in which the skill may be progressed to become more difficult (e.g., it may only occur after the patient is capable of performing the task component a pre-designated number of times, across a certain distance, or at a certain speed). In other words, there is a pre-established, patient and/or task-specific criterion that must be met before progression occurs. Also, the reinforcement provided as part of shaping is not only immediate and rich in information, but positive. This means that reinforcement only emphasizes desirable facets of the movement that will progress the patient closer to eventual performance of the total task. We believe that the continued use of positive reinforcement – as well as the behavioral and motor changes that the patient can readily observe – further increase the likelihood of increasing paretic UE use and, eventually, increasing limb motor ability.

The use of shaping within the RTP protocol is an essential, distinguishing ingredient of mCIT. Later, we describe additional behavioral components that differentiate mCIT from other, conventional, stroke rehabilitative therapies (e.g., neurodevelopmental therapy; proprioneuromuscular facilitation), and likely increase paretic UE use.

2.2. *Restraint of the non-paretic UE*

In addition to systematically querying patients about the tasks that they would like to relearn, we also ask them to identify an active, wakeful, 5-hour period on weekdays. During these pre-identified periods, the non-paretic UE is then constrained. This constraint occurs during the same 10 weeks as when the RTP is delivered. The use of the restraint on the non-paretic UE constitutes both a physical reminder that the patient is not to use it to perform activities, and an inducement to use the paretic UE for home-based activities during the five-hour period. As discussed later, the provision of a detailed "homework" regimen to be performed using the paretic UE is also provided.

It is extremely difficult to approximate the demands and nuances of each individual's home environment when providing therapies within a clinical setting. The limitations associated with practicing tasks in the clinic (rather than in the patient's home environment), and trends toward diminishing in-clinic contact time, argue for protocols that place greater emphasis on structured, home-based practice scenarios. Consequently, we believe that the home use/constraint component is one of the more important mCIT ingredients, because it is this portion of the regimen that provides the unique opportunity for the patient to reintegrate the paretic UE into activities occurring in his/her own home environment. With this in mind, it is worth noting that distributed CIT protocols allow for a large (and, in some cases, larger) number of opportunities to use the paretic UE in the home environment than protocols using more massed practice schedules. Specifically, the distributed home practice schedule used during mCIT provides about a day's worth more practice opportunities in the patient's real world environment than CIT protocols in which the restrictive device is worn daily. Restated, the patient participating in a more distributed protocol like mCIT will receive more of the therapeutic ingredient that is believed to be most critical to re-habituating UE use in the patient's real world environment. This increased number of home-based practice opportunities provides a larger number of opportunities to reintegrate the paretic UE into real-world, valued tasks that are fundamental to community and home reintegration, and a larger number of opportunities to operantly re-condition paretic UE use. Clinicians will want to weigh these decided advantages against the fact that more distributed schedules also require a longer time commitment over more weeks than massed, 2-week schedules. It may be the case that some patients can tolerate – and would prefer – the demands associated with a shorter but more intensive protocol.

The patients' non-paretic UEs are typically constrained by placing their hands in mesh, polystyrene-filled mitts with velcro straps around the wrists. However, there is nothing special about the type of constraint that we have chosen to use, and therapists should incorporate the least constraint needed for a particular patient. In some cases, this may mean no constraint on the non-paretic UE, as a patient may be sufficiently disciplined to use the paretic UE that he/she does not need the physical reminder of the constraint on the other limb. In fact, studies have shown that a positive treatment effect can be realized when the behavioral strategies and clinical parameters of CIT are used, but without the use of a constraint device (Sterr and Frievogel, 2004). We have informally observed that the same appears to be true with mCIT. In other cases, a mitt and a sling may be necessary to fully encourage the client to use the paretic UE in home-based activities.

2.3. The transfer package: High quality ingredients, but how much and which ones?

For nearly a century (Franz et al., 1915), it has been recognized that stroke survivors do not use their paretic UEs for basic activities, even when capable of doing so. Consequently, behavioral strategies are employed during mCIT to address deficits in UE use. Collectively, these behavioral strategies have been termed "the transfer package" by Taub and colleagues (Taub et al., 1994) as their goal is to encourage patients to carry over increased paretic UE use patterns realized during the intervention period to valued occupations in their homes and communities. While integration of the transfer package has been successful in our work, the extent to which the below-described ingredients comprising the transfer package need to be included in mCIT (i.e., dosing) – and, in some cases, whether they need to be included at all – remains unknown.

2.3.1. The behavior contract

No compliance difficulties have been documented in previous mCIT studies. However, many have discussed the utility of a behavior contract in stroke therapies to assure understanding of the procedures involved, and to further promote patient and care partner "buy-in" (Winstein et al., 2003; Morris and Taub, 2001). Thus, to further "hedge our bets" in favor of subject compliance, each patient and his/her care partner (or other witness) meets with the assigned therapist prior to the intervention beginning, and a behavior contract is reviewed and signed. The one-page contract typically includes: (a) An introductory paragraph explaining the purpose of mCIT, a one sentence explanation identifying why we believe the patient is qualified for the therapy, and a sentence noting that the therapy has been shown efficacious. We also emphasize in the introduction that the therapy is a commitment that is not for everyone, and that the contracting session constitutes an opportunity to understand the mCIT parameters more completely, and to opt out. (b) A description of the duration, frequency, location, and typical content of the RTP sessions. This includes verbiage noting that the patient must wear the constraint on the non-paretic UE during RTP sessions, and that he/she will use the paretic UE for all activities during the RTP sessions. (c) A description of the duration, frequency, and content of the home-based "constraint" sessions, including the need to document these home-based activites (as described below). Emphasis is again placed on the fact that paretic UE use will be required during a 5-hour period at home. Since task selection will have already occurred, we also disclose exercises and activities in which the patient will participate during the 5-hour period, (as well as during the clinical sessions). (d) During this time, we also disclose the situations when the constraint is not to be worn (e.g., activities involving safety; activities involving the use of water), and when activities are to be performed with the non-paretic UE.

After reviewing the contract, the patient, witness, and therapist sign the contract. The patient is strongly encouraged to keep the contract in a visible place in his/her home (e.g., kitchen refrigerator). At the beginning of each week, the therapist brandishes the contract, and confirms that the patient remains committed to it. As progress occurs and new challenges are identified, changes are made in the activities denoted in the contract. In this way, the contract acts as a concrete reinforcer of the activities being practiced during the clinical and home sessions.

There are tangible benefits to be gained from the use of a behavior contract, including: (a) A thorough understanding among all parties of the commitments involved in mCIT. Patients and their care partners have often heard of this technique, but are unfamiliar with the demands associated with successful mCIT participation. The explicit discussion of the mCIT components during the contracting process enhances regimen compliance and also "weeds out" patients for whom the demands of mCIT may be too much. (b) The explicit disclosure of situations during which the constraint should/should not be worn likely enhances safety. This is important since a large proportion of the regimen is performed while at home. (c) The contracting session also acts as an opportunity to collaborate with the patient and care partner to "tweak" the tasks that have been identified to maximize adherence, safety, and successful completion (e.g., if one of the tasks is writing, this may be the time when appropriate adaptations to writing utensils may be identified for the home).

Interestingly, we have discovered that the abovementioned benefits associated with behavior contract use are also realized when administering stroke rehabilitative interventions other than mCIT. Consequently, we now administer behavior contracts as part of a number of our interventions. It is our belief that the use of a behavior contract as a compliance and safety technique may be a "universal ingredient" whose potential is yet to be fully tapped in clinical stroke rehabilitation.

2.3.2. Repeated administration of the motor activity log (or a reasonable analog)

In addition to the behavior contract, we also administer the Amount of Use Scale of the MAL at regular intervals (usually on a weekly or every-few days basis). This is intended to act as an additional reminder to use the paretic UE; however, it also allows us to closely monitor paretic UE use patterns. The latter facet is particularly important, given the positive relationships among paretic UE use, brain plasticity, and paretic UE movement increases e.g., (Nudo, 2006). If a patient is not exhibiting longitudinal use changes, more dramatic strategies to encourage use are often implemented (e.g., greater levels of constraint on the non-paretic UE; a higher quantity and/or quality of home-based reminders to use the paretic UE).

In addition to using the MAL as a "pre-post" measure of affected UE use (Wolf et al., 2006), some have used daily administration of the MAL as part of the transfer package (Taub et al., 1994). However, there are no published, dose response data suggesting that daily MAL use is more effective in eliciting paretic UE use changes than every-other day or weekly administrations. There are also no data showing that applying the MAL is more effective than other measures of use. With regard to the second point, the MAL is subjective and some of its activities may not be ones that are most valued by the patient, and/or may be dominant UE-specific (which is problematic if the patient experienced hemiparesis in the non-dominant UE). Thus, daily MAL administration – or even whether one uses the MAL – are ingredients that may be used according to the "flavor" that the clinician prefers. Practical challenges (e.g., the amount of time that the therapist has to administer the MAL), may make it difficult to administer the MAL at all.

Because of the limitations associated with the MAL, we have begun using activity monitors as a gauge of paretic UE use. Activity monitors can be worn non-invasively (like a wristwatch), have a data storage capacity of several weeks, and can be downloaded via an infrared reader unit to a personal computer for subsequent data analysis. Moreover, unlike the MAL, their administration does not occupy precious clinical time, and data collected provides quantitative, objective feedback. Besides our positive pilot experiences, activity monitors, have been successfully used in previous mCIT studies (Page et al., 2002d), and are shown to have good psychometric properties with stroke patients participating in this family of therapies (Uswatte et al., 2006).

2.3.3. *Homework, scheduling of homework, and documentation of homework*

It is common for athletes to use home exercise regimens – or practice regimens outside of the confines of traditional team practices – to augment what has been done during their supervised/coached sessions. In such times, athletes will carefully document their regimens, both as a written reminder of what the exercises that they need to perform, and so that they can monitor progress. With diminishing rehabilitative lengths of stay, it seems reasonable to ask why clinicians do not require the same level of home-based practice from stroke patients, and why clinicians do not regularly have patients carefully document the exercises that they are practicing at home. An advantage of mCIT is the use of such detailed homework regimens, and the careful documenting of what is performed with the paretic UE while the patient is away from the clinic.

The mCIT homework regimens are practiced every weekday of the ten week period, during the 5-hour segments that patients initially identify in collaboration with the therapist. The homework schedule is discerned by our team members, either directly by asking the patient and/or carepartner to identify an active time of arm use, or by using activity monitors. The latter approach is useful because we can quantitatively, objectively, discern when the patient is most active (i.e., when he/she is most likely to use the paretic and non-paretic arms) using the monitors, and assign this as the time when the client should engage in practice sessions at home.

During these times, the "homework" is primarily comprised of practice of tasks identified using the aforementioned methods. However, the therapist may also assign other tasks that target deficient components of tasks that patients want to relearn. For example, if a patient needs to increase his pincer grasp to successfully perform his goal task of grasping a pencil, the therapist may use a variety of tasks during the 5 hour period that encourage pincer grasp practice (e.g., picking up and putting down game pieces) and/or may layer on additional challenges to these tasks as the patients movement increases (e.g., have the patient play Perfection; a game that requires grasping and releasing small pieces onto a small game board within a certain period of time). We have found that this maintains patient interest and compliance to the homework regimen. In fact, as the intervention period progresses, patients often come to the clinic suggesting movements that will target their deficient movements; this is an exciting development that is certainly different from our experiences with conventional therapies. We discourage patients from "breaking up" the 5-hour practice periods, but allow for deviations when it is needed.

We also require patients to document their homework participation using a home use log (sometimes referred to as a "diary" by our patients and team members). Since a large portion of the mCIT regimen is home-based, the primary purpose of the home use log is to allow the therapist to monitor the extent to which the patient is participating in the regimen as assigned, and donning the constraint device(s) as assigned. When compliance is consistently low (as evidenced by the home use log), additional reminders may be instituted in the home, and/or the therapist may remind the patient of the behavior contract that he/she signed during a subsequent clinical session. In recent years, we have examined the efficacy of online diaries, which patients can access through a protected Internet site.

3. Conclusion

The number of stroke survivors exhibiting UE weakness is expected to increase in the next decade. The UE disability levels that these survivors exhibit is often exacerbated by habitual nonuse of the paretic UE.

mCIT is a straightforward, efficacious regimen shown to increase paretic UE use and movement in a variety of environments and phases post stroke. Moreover, mCIT is effective in that it is being practicably administered with high compliance in "real world" settings. The current paper describes the unique behavioral components that comprise the mCIT treatment strategy, beyond what is currently detailed in mCIT clinical trials. Inclusion of all of the "ingredients" of mCIT is fundamental to its cost effective, efficacious administration. It is hoped that the explicit detail and examples used in this paper will further aid its clinical implementation, and ultimately reduce the cost and care needs associated with the rising stroke population.

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