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Chapter 30
Constraint-Induced Movement Therapy for Restoration of Upper-Limb Function: Introduction

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Before starting Constraint-Induced Movement Therapy, it was hard to remember to use my weaker hand for everyday things, but now I just use it without having to think about it.

—Client

Abstract Constraint-Induced Movement Therapy (CIMT) is a research-originated, behavioral approach to neurorehabilitation of limb function after neurologic damage. The intervention utilizes a combination of motor training elements and psychological concepts to facilitate increased use of the affected limb as well as improved movement quality and control. Importantly, CIMT is designed to achieve real-world improvements by behavioral methods which facilitate the incorporation of regained abilities into the persons' spontaneous behavior. Constraint-Induced Movement Therapy is composed of three primary elements: (1) repetitive, unilateral training procedures (e.g., shaping, task practice); (2) a set of behavioral techniques, termed the "transfer package," that promote transfer of therapeutic gains to the life situation; and (3) constraint of the less-affected hand by one of several techniques. Evidence shows that CIMT improves functional use and occupational performance of the more affected upper extremity by reversing learned nonuse and facilitating use-dependent brain plasticity.

Keywords Motor skills • Neuronal plasticity • Rehabilitation • Stroke

Definition and Background

Constraint-Induced Movement Therapy (CIMT) (Taub et al., 1993) improves the functional use of the more affected arm after neurological injury by overcoming learned nonuse and facilitating use-dependent cortical reorganization. It is an intervention based on a behavioral neurorehabilitation model employed with individuals following central nervous system damage (e.g., stroke, traumatic brain injury [TBI]). Basic neuroscience studies with monkeys (Taub, 1977, 1980) preceded studies with humans for (CIMT), and laid the foundation both for discovering the existence of

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learned non-use as a mechanism contributing importantly to the deficit in monkeys with single deafferented forelimbs, and for providing methods to overcome it (Taub et al., 2006a). This phenomenon is found in humans as well after neurologic insult, so that the individual has reduced use of the limb despite motor capability for occupational performance (Taub et al., 1993, 1999). The efficacy of (CIMT) is considered based on two independent but linked mechanisms (Taub et al., 2006a): (1) practice-based counterconditioning of learned nonuse, and (2) use-dependent plastic brain reorganization.

Purpose

Constraint-Induced Movement Therapy has been shown to enhance a client's occupational performance through improved motor ability and remediation of symptoms of learned nonuse. Used both in rehabilitation and habilitation of the more affected arm, (CIMT) has been shown to significantly change not only the more affected arm use and motor ability but also brain function and structure, as demonstrated by neuroimaging (Gauthier et al., 2008; Liepert et al., 2000).

Method

Candidates for the Intervention

Because the clinical practice of (CIMT) is derived from a research foundation that continues to expand, the principles and procedures of (CIMT) will likely continue to be revised. The amount of impairment of candidates has been classified in (CIMT) research by using active range of motion (AROM) of the upper extremity (UE) as a primary criterion (Bowman et al., 2006; Taub et al., 1993, 1999). Early (CIMT) research had recruited participants with only mild-to-moderate stroke deficits (Taub et al., 1993, 1999, 2006b). The research then progressed to treating clients with moderate or moderately severe upper extremity impairment (Taub et al., 1999). More recently, work has been carried out with stroke clients with plegic or nearly plegic hands (Bowman et al., 2006).

The original (CIMT) protocol has also been modified and extended to individuals with traumatic brain injury (TBI) (Shaw et al., 2005), multiple sclerosis (Mark et al., 2008), focal hand dystonia (Candia et al., 1999), lower extremity paresis following stroke or spinal cord injury (Taub et al., 1999), aphasia (CI language therapy) (Pulvermüller et al., 2001; Taub, 2002), or cerebral palsy (pediatric CIMT) (Taub et al., 2004, 2007).

In addition to the upper extremity AROM criterion, selection of research participants has taken into consideration postural balance, cognitive integrity, presence of pain

that might interfere with administration of the therapy, and illness chronicity, to ensure homogenous populations. However, in clinical practice, greater flexibility may be appropriate to treat clients with learned nonuse (Mark and Taub, 2004).

Stroke chronicity of >1 year was used for most research studies, but preliminary evidence suggests that clients in the acute to subacute phases may also benefit (Boake et al., 2007; Dromerick et al., 2000; Wolf et al., 2006).

The use of the AROM criteria assists the therapist with selecting the appropriate CIMT protocol. Clients with mild or moderate upper extremity paresis are usually treated for 3,5 hours per day for 10 consecutive weekdays, while clients with more severe upper extremities paresis are usually treated 3,5 hours per day for 15 consecutive weekdays (Mark and Taub, 2004).

Epidemiology

The prevalence of stroke-associated disability in the general population has been reported to range from 173 to 200 per 100,000 (SASPI Project Team, 2004), while the estimated proportion of stroke survivors who are dependent in their activities of daily life (ADL) ranges from 30% to 50% (Carroll, 1962; Gresham et al., 1975).

Seventy percent of chronic stroke survivors are estimated to have motor deficit (Anderson et al., 2004). Studies have not yet determined what proportion of adult stroke clients with an acute hemiparesis in a subacute or a chronic stage will meet inclusion criteria for CIMT.

In a recent prospective study, 41 out of 87 people suffering from a stroke had moderate to severe hemiparesis (Prabhakaran et al. 2008). The great majority of these 41 clients (83%) recovered to at least 70% of the maximum motor gain possible by 3 months after stroke onset. These findings suggest that most acutely hemiparetic stroke clients eventually regain substantial movement ability that would appear adequate for training tasks. However, further research is needed to determine what proportion of stroke patients who are in a subacute or a chronic stage and having persistent learned nonuse of the paretic upper extremity, and therefore would be recommended to undergo CIMT.

Individuals with diagnoses other than stroke who meet the AROM criteria may also be appropriate for CIMT.

Settings

Research to date indicates that CIMT is well suited for implementation among outpatient and in home health settings. Studies have suggested that CIMT in an acute inpatient rehabilitation setting may be efficacious (Boake et al., 2007; Dromerick et al., 2000).

The Role of the Occupational Therapist

Constraint-Induced Movement Therapy may be conducted by an occupational therapist or a physiotherapist. The role of the therapist in CIMT is to ensure the integrity of the standard intervention while focusing on the unique needs and goals of each client. The occupational therapist (OT) may be required to adopt a variety of roles, including evaluator, tester, trainer, coach, problem solver, and encourager. Therapists must employ therapeutic skills in observation, listening, problem solving, behavioral management, task analysis, strategy development, safety awareness, and risk assessment, especially with regard to appropriate mitt use. Splinting, adaptive equipment selection, adaptive strategy development, and other conventional interventions are also employed to the CIMT.

In the clinical application of CIMT, it is important to duplicate the procedures that were used in the research protocols, including ensuring that prospective clients have similar movement deficits. Enrolling clients who do not meet the minimal movement requirements for the specific protocol may lead to poor results as well as frustration on the part of both the therapist and the clients.

It should be noted that many procedures in CIMT are not typically employed in conventional rehabilitation. In our experience, therapists have often voiced their unfamiliarity with the types of procedures utilized in CIMT, particularly with the techniques of the transfer package. It is important that therapists who plan to implement CIMT should first be adequately trained.

At the University of Alabama at Birmingham, CIMT training consists of a semiannual 5-day continuing education course that includes 2 days of a hands-on lab practicum accompanied by feedback on performance of procedures to ensure proper administration of the CIMT treatment.

Results

Clinical Application

Constraint-Induced Movement Therapy consists of three main components, which are demonstrated in Fig. 30.1:

- Repetitive, functionally relevant, task-oriented training of the more impaired limb.
- Employment of a set of behavioral techniques known as the *transfer package* that are designed to facilitate carryover of gains made in the research laboratory or clinic to the generalized life situation.
- Procedures to constrain use of the more affected extremity, including physical restraint of the less affected arm (Taub et al., 1993; Uswatte et al., 2006a).

Shaping (Taub et al., 1993; 1994), one of the primary training technique employed, is a systematic behavioral procedure whereby progress is achieved in small steps by successive approximations throughout multiple timed trials that use frequent detailed

Fig. 30.1 An example of administering shaping with a client who had suffered from a stroke. The mitt on the less-affected hand greatly reduces the ability to use that extremity.

feedback and encouragement. With adults, the shaping process is usually broken up into blocks of ten trials each, and the repetitions of the task are timed or the number of repetitions completed in a set timed period, (e.g., 30 sec.). The data from each trial are recorded and reported immediately to the client. Progression of the shaping task requires consistent improvement in previous performance.

The transfer package (Taub et al., 2006a) utilizes selected behavioral techniques: home diary, behavioral contract, home skill assignment, daily administration of the Motor Activity Log (MAL) (Uswatte et al., 2006b), problem solving, and maintenance of a daily schedule. In the transfer package, protocol adherence is bolstered by maximizing client accountability, engaging the client in problem solving, and prompting the client to use the more affected limb during occupational performance. The transfer package makes compliance with the CIMT protocol the responsibility of the client; therefore, the functional achievements are his own.

A *signature feature* of CIMT protocols is the use of a padded safety mitt on the less affected hand as a physical restraint. The mitt is worn for a target of 90% of waking hours during the therapy period and is removed during personal hygiene and where safety might be comprised through its use. Mitt use is only one way of constraining the client's behavior to increase use of the more affected upper extremity and appears not to be the most important feature (Uswatte et al., 2006a).

Two outcome measures with established reliability and validity have been consistently used with CIMT research:

- The MAL (Taub et al., 1993; Uswatte et al., 2006b), a structured, scripted interview that measures the amount and quality of spontaneous arm use during activities of daily living (ADL) in the real world.
- The Wolf Motor Function Test (WMFT) (Morris et al., 2001; Wolf et al., 2001, 2005), which is a standard laboratory test of motor ability. The WMFT is not required when providing CIMT in clinical practice (Mark and Taub, 2004).

How the Intervention Addresses Impairments, Activity Limitations, and Participation Restrictions

After CIMT, motor impairments of the more affected upper extremity show positive changes, in a large majority of cases and the client is better able to engage the limb in occupational performance. In addition to the motor and functional use gains, evidence has shown that clients report quality of life improvements that are sustained for at least 2 years after undergoing CIMT (Wolf et al., 2008).

Evidence-Based Practice

Constraint-Induced Movement Therapy is an evidence-based approach that is grounded in a strong empirical foundation that has been evolving over the last two decades. Randomized controlled trials (RCTs) have been published with positive results (Shaw et al., 2005; Taub et al., 1993, 1999, 2004, 2006b, 2007). The Extremity Constraint-Induced Therapy Evaluation (EXCITE) trial (Wolf et al., 2006), a large, multisite RCT of CIMT for the upper extremity after stroke, was the first of its kind for rehabilitation of the upper extremity in the United States. Additional evidence continues to emerge from around the world, with over 200 papers published that have examined CIMT all yielding to our knowledge successful findings.

Discussion

The CIMT model brings with it engaging concepts and challenging principles that offer new perspectives and opportunities for rehabilitation. As this model has been disseminated, criticisms of CIMT have been voiced, including concerns with safety, questions about the distinctiveness of the intervention, concerns for the acceptability of CIMT to clients, and reimbursement issues. Mark and Taub (2004) discuss these issues in detail.

Constraint-Induced Movement Therapy is cost-effective in that it has proven outcomes. With proper implementation, one can anticipate a specific amount of average functional recovery. CIMT enables a breakthrough for participants toward

real-world functional recovery and not only symptom management after stroke. Automated forms of CIMT have also been successfully studied to reduce the cost of administration of shaping by a therapist, which may allow the therapist to work with more than one client at a time (Taub et al., 2005)

Future studies should more closely examine the factors responsible for the therapeutic effect of CIMT, as well as attempt continued extension of CIMT to new populations of clients who display learned nonuse. Studies that combine traditional therapeutic modalities and approaches with CIMT to maximize gains for lower functioning clients are also needed.

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