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Chapter 31
Constraint-Induced Movement Therapy for Restoration of Upper-Limb Function: Hemiparesis Application

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CIT has helped me mentally as well as physically. In the 2-week period, I kept finding I could do things every day. I feel it's given me more confidence.

—Client

Abstract Constraint-induced movement therapy (CIT) is a highly specialized form of rehabilitation for those with upper-limb paresis. The intervention uses 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, CIT is designed to achieve real-world improvements through behavioral measures that facilitate the incorporation of regained abilities into the person's spontaneous behavior.

Keywords Constraint-induced movement therapy • Learning • Neuronal plasticity • Shaping • Rehabilitation • Upper extremity paresis.

Definition and Background

Constraint-induced movement therapy (CIT) works on the premise that the brain can reorganize itself after sustaining damage to the motor area, and that these processes are facilitated through the two treatment principles: (1) extensive upper-limb training, and (2) constraining the unaffected limb. The intervention encourages brain reorganization to increase its motor capacities (Kim et al., 2004) and the cortical space devoted to the affected upper limb (Liepert et al., 2000).

The upper-limb-training component of CIT involves the massed practice of everyday tasks or parts thereof under the guidance of and with the feedback from a CIT therapist. Here, the therapist implements the principles of shaping, a psychological concept derived from the behaviorist tradition, which involves: (a) quantifying and very frequent immediate feedback concerning improvements in the speed and quality of movement (QOM), (b) selecting tasks that were tailored to address the motor

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deficits of the individual client, (c) modeling, prompting, and cuing of task performance, and (d) systematically increasing the difficulty level of the task performed in small steps when five trials of improved performance occurred. (Taub et al., 2006, p. 1046)

In addition to the training of the affected arm, the unaffected limb is constrained so as to encourage the use of the affected arm outside the treatment setting and to reverse "learned nonuse." The latter is a learned behavior established during the diaschisis phase in early recovery, and it occurs when the affected limb is associated with failure to achieve goals; therefore, unaffected arm use, associated with successful functioning, is reinforced. Constraining the unaffected arm enforces the use of the affected arm and breaks the chain of reward contingencies, which establish and sustain the learned nonuse.

Constraint-induced movement therapy aims to increase the use, quality, and control of movement in the affected limb. The functional improvements obtained through the intervention enhance clients' confidence in using the affected limb in everyday situations, thus contributing to an enhancement of well-being and quality of life.

Method

Candidates for the Intervention

Candidates are clients with upper-limb paresis who have sustained brain damage because of stroke, traumatic brain injury, cerebral palsy, or tumor. Although CIT-based clinical trials to date use strict inclusion criteria, CIT has been successfully applied to clients with various causes and prognoses of hemiparesis, and at various stages postincident. Brain trauma is often associated with other persisting symptoms, ranging from physical ailments to psychological and cognitive disturbances, which may be possible areas for concern when considering a client for CIT. This is particularly true concerning the use of the unaffected-arm constraint, which forces patients to face the incapacities of their affected arm and the consequences thereof. Adequate psychological supervision alongside CIT provision is therefore mandatory, in particular when residual abilities are very poor and the incapacitation through the unaffected arm constraint is severe.

Most importantly, clients must have *some* residual movement in the arm and hand of the affected limb. Minimal movement is usually 10 degrees for digits and 10 degrees for the wrist. However, this criterion is not mandatory. Gross arm movement must also have some functioning to enable carrying out activities of daily living. High spasm can be challenging for the shaping training, and present difficulties with everyday living activities while wearing the constraint. Persons with full paralysis of the affected limb will not benefit from the CIT protocols currently available.

Constraint-induced movement therapy is a versatile intervention from which children, adults, and older adults can all benefit.

Settings

At present, CIT is available privately at the Taub Therapy Clinic in Birmingham, Alabama, and interested persons can apply to participate in various clinical trials worldwide. Implementation of CIT as a widely available form of rehabilitation is the current aim. In some countries, such as Germany, this is well underway. Other than this, CIT is applied in a research context in some European and American research centers (including the University of Surrey, England). Furthermore, practitioners presently use some components of CIT, but rarely in the formalized and systematic way that underlie all successful clinical trials of CIT.

The Role of the Therapist Applying the Intervention

The therapist-client interaction (Fig. 31.1) in CIT therapy is very intense, not only because of the length of daily treatment but also because of the therapist's functions, which are as follows:

Fig. 31.1 A constraint-induced movement therapy (CIT) session. The therapist helps guide the client's movement toward the desired goal.

- Setting realistic goals and agreeing to these in a treatment contract.
- Specifying the task program for the behavior shaping in accordance with the goals, and reviewing the task in accordance with progress.
- Providing psychological support in problem-solving sessions. Monitoring the client's progress within and between sessions.

Setting Realistic Goals

Realistic goals for CIT tasks and functional aims at home are based on what the therapist and client feel is achievable. The goals are agreed upon and formulated in a treatment contract. The client input in goal-setting is an important motivational factor, and may actually encourage CIT recipients to work toward more complex goals in the longer term.

Behavior Shaping

The application of *positive reinforcement* allows the therapist to shape affected limb use toward the desired behavior. Positive reinforcement may be in the form of verbal praise, visual feedback, or quantifying actual improvement. The latter is particularly important and is reflected in the design of CIT tasks, which entails a high level of formalization and the provision of measurable performance indices.

Psychological Support

Constraint-induced movement therapy directly addresses disability, which is usually paired with psychological consequences. Therefore, good client relation skills are essential to promote a psychologically supportive environment. Encouraging clients to reflect on their experience during sessions is a good opportunity to reinforce progress and judge clients' psychological and physical state. This enables the therapist to help ease any frustration and decide whether a rest is required. Ample motivation and positive feedback are an essential part of CIT to further reinforce affected arm use with a favorable outcome.

Monitoring Progress

Constraint-induced movement therapy session content and patient achievement are documented for each task. This is usually reported as the number of repetitions per trial, the number of rests, and time to complete the task. A diary of activities is used to support and track affected arm use at home, and can further be used to highlight areas of difficulty that are subsequently addressed during problem solving.

Results

Clinical Application

During the training sessions, clients practice motor tasks with the affected upper limb with the supervision and encouragement of the therapist. Traditionally, training is administered for 6 hours a day over ten consecutive weekdays. The shaping technique is used to elicit the desired movement from the affected limb by gradually increasing task difficulty. Tasks can be directed at elements of upper-limb movement (e.g., using a spoon involves the elbow, wrist, and grip) or at specific movements (e.g., concentrating on moving individual fingers), and are practiced in a repetitive fashion using tangible feedback on task performance. The unaffected arm constraint, typically a forearm splint (Fig. 31.2), is worn for 90% of waking hours in order to force the use of the affected limb throughout this time.

Thus, clients are encouraged to employ their affected arm in functional tasks at home. These tasks are initially outlined in a treatment contract and reviewed daily. Difficulties or successes in the home environment are addressed in problem-solving sessions, which proceed every training day.

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

Following CIT, participants experienced a significant increase in real-world arm use, measured by the Motor Activity Log (Unswatte et al., 2006).

Recent research has extended the traditional motor outcome measures to include quality of life. Participants in a modified CIT program reported greater holistic recovery from the effects of their stroke on the Stroke Impact Scale, compared to

Fig. 31.2 The constraint inhibits full use of the arm and fingers, thus forcing the use of the affected arm.

those who received a traditional form of rehabilitation (Wu et al., 2007). Dettmers et al. (2005) found improvements in psychosocial domains such as social participation and communication from pretreatment to 6-month follow-up.

Evidence-Based Practice

Scientific Support

The empirical evidence for the efficacy of CIT is strong. CIT increases motor ability and real-world arm use compared to control treatment, and these changes persist for up to 2 years (Taub et al., 2006). The effectiveness of CIT was further demonstrated in a multicentered clinical trial (Wolf et al., 2006). Comparable findings have been obtained in a traumatic brain injury (TBI) population (Shaw et al., 2005). Modified protocols are also effective. Shorter daily therapy time produced lesser but significant improvements in objective and subjective motor function (Sterr et al., 2002). A shaping-only protocol involving 90 minutes of daily training over 3 consecutive weeks also increased motor function and arm use compared to a control group (Sterr and Freivogel, 2003).

Other Considerations

The Reality of Constraint-Induced Movement Therapy

A particular issue surrounding CIT is use of a constraint, which may pose safety risks for some clients. One way to overcome this is for clients to sign a treatment contract by which they agree not to wear the constraint in situations that compromise their safety, such as with the use of walking aids. In addition, it has been shown that improvements in upper-limb use can be obtained even if constraint is not used (Sterr and Freivogel, 2003). However, longer follow-ups are needed to assess the long-term outcome of shaping-only protocols.

Another area of concern is the high demand of the intervention, which may increase sleepiness and mental exhaustion. Clients therefore need to take extra caution when returning home, ensuring appropriate rest after CIT, and getting a good night's sleep for subsequent sessions.

Discussion

Wider Application of Constraint-Induced Movement Therapy

The adaptive nature of CIT allows the traditional protocol to be applied to patients with varying needs, time constraints, and health care resources. CIT has also

been successfully applied to other motor movement problems including lower-limb paresis and balance (Vearrier et al., 2005). The foundations of CIT theory have strong potential in nonmotor conditions such as aphasia (Meinzer et al., 2007) and chronic pain syndrome (Pruimboom and van Dam, 2007).

Future Research

In realistic circumstances, the original protocol of 6 hours of CIT per day is likely to exhaust resources and not be applicable in all patients. The systematic testing of more practical CIT variants is therefore essential for CIT to become a standard health care procedure. Novel forms of treatment delivery, such as online CIT, have shown promising results and warrant further exploration (Page and Levine, 2007).

Conclusion

"So now I have finally overcome the major drawbacks in my life so that they have driven me forwards, and that's all because I undertook CIT." CIT, a truly life-changing intervention, has been termed the most successful treatment for those suffering from upper-limb hemiparesis. More and more rehabilitation consultants are taking an interest in CIT, making it available for the clients who need it. CIT is an interdisciplinary intervention that marries social sciences and psychology with physiotherapy and occupational therapy. Fusing disciplinary boundaries in education and practice will be the key to the successful translation of this intervention into clinical practice.

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