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Alternate Delivery of a Group Modified Constraint Induced Movement Therapy

by

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Abstract

Background: This study evaluated the efficacy of a modified Constraint Induced Movement Therapy (mCIMT) program delivered in a group format. *Objectives*: To determine if: 1) group mCIMT participants would show statistically significant and clinically important improvements; and 2) the effect size of a group mCIMT would be similar to those reported for individual mCIMT. *Methods:* Fifteen participants attended a group mCIMT program consisting of three participants supervised by two staff. *Results:* Participants achieved statistical and clinically significant improvements in motor recovery (Wolf Motor Function Test), functional use (Motor Activity Log) and participation (Canadian Occupational Performance Measure). These improvements were maintained over three months. The effect of group mCIMT was comparable to individualized mCIMT programs with similar protocols. *Conclusion:* Group delivery of mCIMT produces meaningful results similar in effect to individualized mCIMT and therefore is potentially an effective way of extending availability of this program without placing overwhelming demands on health care resources.

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List of Abbreviations

ADL – activities of daily living

aou – amount of use (MAL scale)

ARAT – Action Research Arm Test

BAT – bilateral arm training

CAHAI – Chedoke Arm and Hand Activity Inventory

CIMT – Constraint Induced Movement Therapy

CMSA – Chedoke McMaster Stroke Assessment

COPM – Canadian Occupational Performance Measure

CST – cortico-spinal tract

dti – Diffuse Tensor Imaging

EXCITE – Extremity Constraint Induced Therapy Evaluation

fas – functional ability scale (WMFT scale)

FIM – Functional Independence Measure

FMA – Fugl-Meyer Assessment of Motor Recovery

fMRI – functional Magnetic Resonance Imaging

GPT – Grooved Pegboard Test

GRH – Glenrose Rehabilitation Hospital

MAL – Motor Activity Log

MCID – Minimal Clinically Important Difference

mCIMT – modified CIMT

MDC – minimal detectable change

NDT – neurodevelopment technique

NIHSS – National Institutes of Health Stroke Scale

OT – Occupational Therapist/Occupational Therapy

PNF – proprioceptive neuromuscular facilitation

PT – physical therapy

qom – quality of movement (MAL scale)

RCT – randomized control trial

SIS – Stroke Impact Scale

TA – Therapy Assistant

TMS – Transcranial Magnetic Stimulation

VECTORS – Very Early Constraint Induced Movement Therapy during Stroke Rehabilitation

WMFT – Wolf Motor Function Test

Chapter 1: Introduction

There are approximately 300,000 Canadians living with some form of disability caused by stroke and it is estimated that 80% of survivors of stroke experience acute arm weakness with only one-third achieving full recovery.[1,2] Constraint induced movement therapy (CIMT) is an established treatment for arm and hand weakness as a result of stroke and the Evidence-Based Review of Stroke Rehabilitation states that there is strong evidence supporting its use for individuals with some active wrist and hand movement.[3] CIMT improves function not only in the research laboratory but also in the ability to use the arm in functional or 'real world' activities, which has been identified as the single most important factor in stroke survivors rating of their own recovery.[4] CIMT is an intensive treatment and traditional CIMT protocols require one to one participant to trainer ratio for six hours daily for ten treatment days over two weeks.[5] This is obviously a very time and resource expensive program; one that may not be feasible outside a research setting. [6] Subsequently, there have been studies on alternate deliveries of distributed [7,8] and modified CIMT[9-11] where total number of treatment hours were reduced, equivalent hours were extended over a longer time frame, or certain elements of the protocol were altered. Many of these programs had promising results; however, all of these variations continue to involve one to one treatment. There have been several reports of CIMT delivered in a pair or group setting, however, it was not the primary objective of these studies and the effects were not directly analyzed. [12-14] To the best of our knowledge, only one

study has directly evaluated a group treatment of CIMT and they reported small effect sizes for the motor recovery and functional use.[15]

In 2007, the mounting evidence for the efficacy of CIMT garnered a great deal of interest among clinicians and rehabilitation administrators. As a result, the Glenrose Rehabilitation Hospital (GRH), the largest freestanding, tertiary rehabilitation hospital in Canada, provided funding for the principal investigator to learn how to develop, administer, and evaluate a CIMT program. Training consisted of a course at the University of Alabama at Birmingham, home of a CIMT Research Group headed by Dr. Edward Taub. Additional training, especially about the logistics of setting up a clinical CIMT program, was held at Emory University in Atlanta, Georgia in the research lab of Dr. Steven Wolf. As a whole, training detailed all the components of CIMT, educated about the most recent evidence regarding CIMT, and provided clinical recommendations that formed the basis of the CIMT program at the GRH.

The greatest challenge in providing a CIMT program at GRH was maximizing limited resources, in an effective and efficient manner, in order to reach the greatest number of clients. A pilot project of a group CIMT was initiated as part of the Outpatient Stroke Program and ran for one year with fifteen participants. The results were excellent and after completion of the pilot project, referrals for clients who met the same inclusion criteria from the Adult Brain Injury Program were also accepted. Outcomes remained positive and no adverse effects from memory, behavioural or other cognitive issues were encountered.

The results achieved in the pilot and subsequent clinical care encouraged further study to methodically evaluate this unique approach.

The overall objective of this study was to evaluate a group approach for modified CIMT (mCIMT), where three participants attended simultaneously with one occupational therapist and one therapy assistant. We specifically assessed the effect of the group mCIMT program on the outcomes of motor recovery, functional use, and participation immediately after the program and at one and three months post program. We also wanted to know if any changes as a result of group mCIMT were similar in magnitude to those reported for mCIMT programs delivered individually. We hypothesized that: 1) following group mCIMT participants would show statistically significant and clinically important improvements on motor recovery, functional use, and participation, and that improvements would be maintained at three months; and 2) the effect size of a group mCIMT program would be at least equal to those reported for individual mCIMT programs.

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Chapter 2: Literature Review

2.1 History of CIMT

Constraint Induced Movement Therapy has its roots in two fields: psychology and rehabilitation science. The original concepts were developed by Dr. Edward Taub, a psychologist who discovered that if monkeys were given a dorsal rhizotomy, they would not use the insensate limb despite having intact motor pathways.[1] The monkeys' intact limbs were then restrained and a behavioural training program was initiated whereby they were rewarded for progressive reach and grasp activities with their affected limb. If the restraint was worn for only a short period, the monkeys quickly reverted to using the intact limb when it was removed. However, the longer the restraint was worn, the greater the length of time the monkeys continued to use the affected limb after the restraint's removal. Taub felt there was a cycle of 'learned-non use', whereby the monkeys were reluctant to use their affected limb because it was frustrating, painful, or awkward. He hypothesized this resulted in a negative, injury-dependent cortical reorganization in the area affected by the "stroke". However, if the monkeys were forced to use the limb, the cycle could be broken and positive, use-dependent, cortical reorganization could occur. Years later, with the advent of cortical mapping, this was proven to be true.[2]

Rehabilitation scientists began transferring these concepts to human trials and in the 1980's 'Forced – Use Therapy' became increasingly popular.[3,4] During this type of therapy, hemiparetic participants wore an arm sling and hand splint restraint on their unaffected upper limb and engaged their more affected arm in

activities in their home environment which were discussed with, but not directly supervised by, a therapist. The results were promising but more work was needed to determine whether 'forced use' could produce sustained results. The therapy continued to evolve to include components beyond the restraint and in 1998 Taub et al published 'Constraint –Induced Movement Therapy: a new approach to treatment in physical rehabilitation'.[5] Here the standardized protocol of repetitive, task specific training, behavioural package, and restraint of the less affected upper extremity was introduced.

2.2 Components of CIMT: "The therapeutic package"

While multiple studies have been published under the title of constraint induced movement therapy, one must read carefully to ascertain what the actual treatment consists of. Published reports include circuits,[6] group activities, housework or crafts,[7] individually chosen functional tasks[8] or various combinations of repetitive, task specific training. There are a wide variety of effects reported and it has been theorized that this may be due to failure to correctly implement all three components of the CI protocol.[9,10] In 2006, Dr. Taub's research laboratory published a detailed characterization of the protocol [11] which includes the following components:

2.2.1 Repetitive, Task Specific training which can be divided into two sub categories:

Adapted Task Practice (also called Shaping) is a form of behavioural training or operant conditioning whereby patients attempt to achieve a movement goal by approaching it in small steps that become

progressively more difficult. The task is practiced during timed trials and repeated ten times per session, thereby providing intense, repetitive and task specific training. As the participant improves in timing and quality the activity can be 'shaped' or modified closer to the ultimate goal. This training is individualized and the trainer provides near constant feedback and supervision. Examples might include "how many cones can you move in 30 seconds" or "how long does it take you to put in 8 pegs"?

Repetitive Task Practice involves functional activities performed on a continuous basis for 15-20 minutes. Global feedback is provided throughout and the activities can be graded to be more challenging as the training progresses. Examples might include "how many vegetables can you peel and cut in 15 minutes" or "how long does it take you to fold this basket of clothes?"

2.2.2 The Behavioural Package

The Behavioural Package includes a variety of different strategies to encourage use of the arm and hand in everyday, or 'real-world', activities. Taken together, these strategies provide an opportunity for participant monitoring, self reflection, accountability and problem solving. Clinically, this "Transfer Package" as Taub's lab calls it, is invaluable in encouraging use of the weaker arm outside of therapy.

The tools include the following:

The Home Diary is a form participants fill out nightly that documents their activities and mitt wear. The focus is not only when the mitt was removed, but why it was removed and what the more affected upper extremity is doing at that point in time. This provides an opportunity for the participant and the therapist to problem solve ways the weaker hand can remain involved even when the mitt is off.

A **Home Skills Assignment** is a comprehensive list of every day activities completed outside of therapy; at home, around the yard, in the community. Every day the participant and therapist identify 10 items off the list for the participant to engage in for approximately half an hour that evening. Typically some are easy (for example: open the shower curtain) and some more challenging (for example: unlock front door with key). The goal is to engage the weaker limb in exploring the environment outside of therapy. Participants are sometimes surprised to discover activities they have not tried in some time are achievable. It also allows problem solving to discover alternative ways to achieve tasks involving the weaker limb.

Home Practice of specific exercises (for example: strength training, range of motion exercises) is sometimes provided but this is dependent on participant's endurance and activity level at home. It is preferable to engage in real world 'home skills' as opposed to practicing 'therapy' type activities. However, if participants are quite sedentary and not doing

much with the weaker arm in the evening, then home practice is sometimes assigned.

A **Behavioral Contract** is developed, agreed upon, and signed by both the participant and the therapist on the first day and reviewed at the half way point of the program. This contract outlines which daily activities outside of therapy can be accomplished with the mitt on, which require mitt removal but the weak hand can still participate, and which activities should be performed only with the less affected upper extremity. These are typically safety related items such as using a mobility aid, drinking hot liquids or driving. Activities that require mitt removal are grouped together over one time period if possible and problem solving about how the weak arm can be involved in a safe manner are discussed. If it is not feasible to complete an entire activity with the weaker hand, incremental goals can be set, such as 'eat one meal a day' or 'eat 50% or each meal' or 'hold cup when taking medicine'.

2.2.3 Restraint of the less affected upper extremity

By far, this has been the most easily identifiable component of CIMT. While early studies utilized a sling or hand splint, concerns over safety and balance have contributed to the more widespread adoption of a padded safety mitt, similar to those used in acute care to prevent patients from pulling out tube or lines. The goal is to wear the mitt for 90% of waking hours, while removing it for any activities involving water or in

any situation where safety might be compromised, for instance to use a mobility aid or drinking hot liquids. Emphasis is placed not just on restraint of the less affected extremity, but also on techniques to enhance use of the more affected extremity.

Though many studies fail to make mention of which elements of CIMT have been utilized, there has been some work looking specifically at the contributions of the various components. In an analysis of adaptive versus repetitive task practice it was found that those with a lower level of motor recovery benefited more from repetitive task practice and those with higher functioning had greater improvements with adaptive task practice.[12] This is in contrast to the clinical experience of Dr. Taub's CI Research Lab, who state they feel lower functioning patients respond better to adaptive task practice.[13] They theorize this is because adaptive task practice is more systematic and standardized and that more feedback is given.

The same group compared chronic stroke clients who used various combinations of restraint (sling, half glove, none) and training (adaptive or repetitive task practice).[14] There were no significant differences between any of the various combinations of elements at the conclusion of the two week intervention but in subsequent two year follow up, both sling groups (sling + adaptive task practice and sling + repetitive task practice) had better retention of gains compared to half glove or no restraint. The sling and repetitive task practice group had a trend towards improved outcomes compared to the sling and adaptive

task practice group. Other studies of the restraint component have supported the theory that the mitt contributes the least to therapeutic efficacy of the program. In 2006, Brogardh and Sjolund took two groups of recent CIMT participants and had one group continue to wear a mitt for an additional 21 days after completion of the program.[15] They found no additional benefit from ongoing mitt use. In 2009, this group compared sub-acute CIMT participants with and with out mitt and also found no differences.[16] In a one year follow up of this study, there still remained no differences between the groups and all participants retained gains made in CIMT.[17] As Wolf summarized "there is no need to be smitten with the mitten". [18]

2.2 Mechanisms of Action

One mechanism that is thought to be responsible for the improvements seen in CIMT is overcoming *learned non-use*[19]. According to this psychological theory, learned non-use develops when an injury results in individuals being less likely to use their weaker arm because it is frustrating, tiring, or they are 'punished' in behavioural terms (See Figure 2-1).

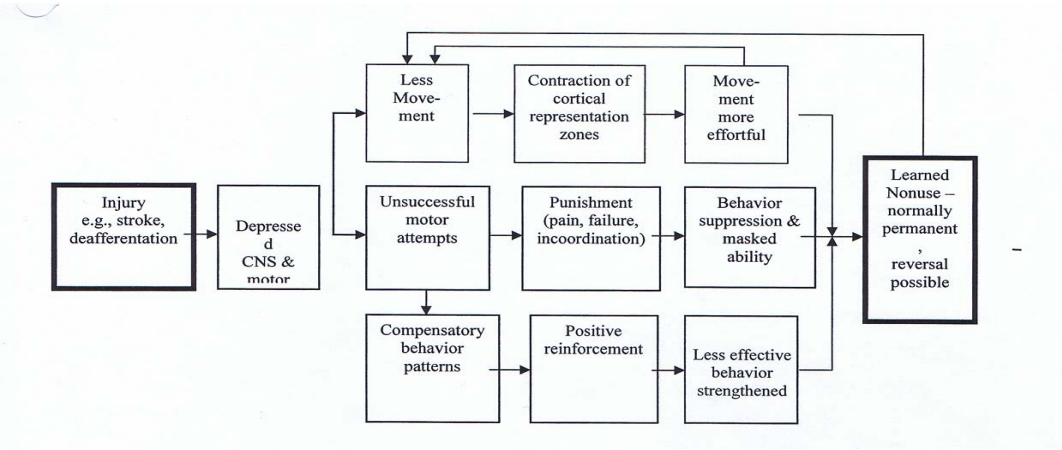

Figure 2-1: Schematic model for development of learned non-use.

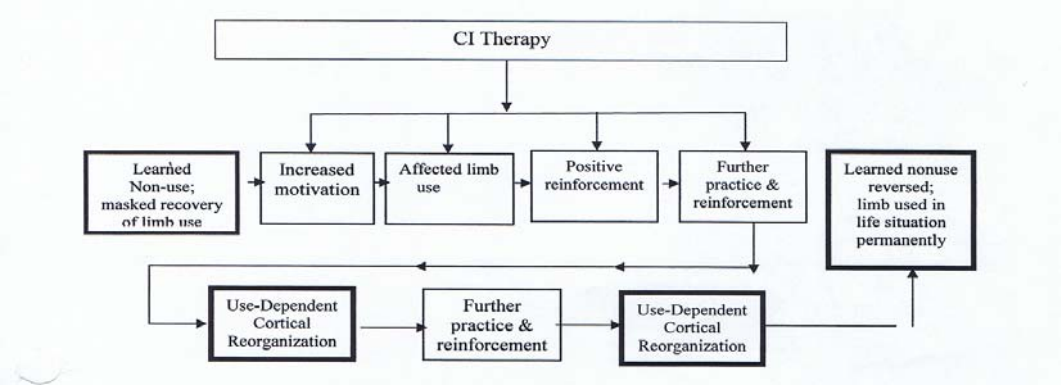

Figure 2-2: Schematic model of mechanism for overcoming learned non-use.

*Figures from UAB Training for CI Therapy Manual, used with permission of author (see Appendix E).

This non-use results in cortical contraction or injury dependent cortical reorganization in the area affected by the injury. Participation in CIMT can combat learned non-use by increasing motivation to use the more affected limb, unmasking previously unused recovery, providing positive reinforcement, and allowing the opportunity for further practice and reinforcement. This in turn can contribute to the second mechanism of action: cortical expansion of the damaged areas or use-dependent cortical reorganization (See Figure 2-2). .

Despite the fact that use dependent cortical reorganization is one of the most reproducible findings in the field of neurorehabilition, these changes have not been proven to be responsible for enhanced motor or functional recovery in CIMT or any other therapy.[20] Two methods of examining this mechanism of action in CIMT are Transcranial Magnetic Stimulation (TMS) and functional Magnetic Resonance Imaging (fMRI).

During TMS, a magnetic field is created about a coil over the skull which, if applied at sufficient intensity, can induce excitation of the upper motor neurons. This in turn is relayed to the alpha motor neurons of the spinal column which produces a motor evoked potential (MEP) at the muscular level. This can be measured with electromyography (EMG) and in this way a 'motor map' is created showing cortical stimulation in specific spot results in excitation of a specific muscle. Fifteen years ago, Nudo et al demonstrated in squirrel monkeys that this map could be altered in response to specific motor skill training.[21] If the monkeys were given skilled reaching training, the cortical representation of their digits expanded. If they were trained in a task that involved pronation and supination of their forearm, as in turning a knob, the representation of their forearm expanded.

The same findings have been demonstrated in humans and were first linked with CIMT by Liepert et al.[2] This study showed enlargement in the motor map of the lesioned hemisphere after a course of CIMT which corresponded with improvement in measures of real world use (Motor Activity Log). When the 13 subjects with chronic strokes were seen for follow up six months after the program, this correlation persisted and the number of TMS activation points had normalized between lesioned and non-lesioned hemispheres. This equalization between hemispheres was thought to be more similar to undamaged brains and represented greater efficiency. Similar results were seen in sub acute stroke survivors receiving the same treatment protocol.[22] These participants showed improved motor outcomes (Wolf-Motor Function Test) and larger cortical maps, but only of borderline statistical significance. ($p < .053$).

Functional Magnetic Resonance Imaging (fMRI) uses MRI to measure the brain's vascular response to increased demand for oxygen and glucose during movement. Because any movement of the head results in distorted images, fMRI studies are typically limited to upper extremity activity.[23] Levy was the first to use fMRI to show changes in cortical excitation that correlated with motor improvement after CIMT.[24] However, there were conflicting results with one of the subjects showing increased activity in the peri-infarct and *contra*lesional areas and the other in the *ipsi*lesional side. Johansen-Berg showed similar *ipsi*lesional activation after CIMT, as well as bilateral cerebellar activation that correlated with motor improvements.[25] Various other studies demonstrate a variety of patterns in terms of laterality, activation, and inhibition pre and post CIMT.[26-29] Mark, Taub, and Morris summarize their analysis of the data by stating that if CI enlarges motor maps (measured by TMS) and decreases metabolic demands (measured by fMRI) of the more affected hemisphere, then overall, it makes hand movements more efficient.[30]

While differences in methodology and analysis might explain some of the discrepancies in imaging studies of CIMT, Wittenberg and Schaechter theorize that other factors such as time of imaging (differing neuroplastic processes before, during, or after therapy), infarct location, involvement of cortico-spinal tract, and the differences of structural plasticity between gray and white matter have a role we do not yet understand.[20] Tarkka and Kőnőnen point out that regardless of whether modulations in brain function are excitatory or inhibitory, they are a response to task-specific exercises and that a learning component is required to

incite these changes.[31] They surmise that "CIMT provides an increasingly difficult motor challenge with a motor learning component and thus provides activation in the brain that may enhance reorganization related to motor control" (p. 63).

2.4 The EXCITE Trial

In the fall of 2006, the largest ever study of CIMT was published in Journal of the American Medical Association (JAMA). It was the first non-pharmacological study of stroke rehabilitation funded by the National Institute of Health in the United States. The Extremity Constraint Induced Therapy Evaluation ("EXCITE") was a prospective, single-blind, randomized, multi-site clinical trial of 222 participants 3-9 months post stroke.[32] Study participants were stratified into higher functioning (minimum 20 º wrist extension and at least 10 º of extension at each metacarpopharlangeal and interphalangeal joint of all digits) and lower functioning (minimum of 10º active wrist extension, 10º thumb abduction/extension, and 10º of extension in at least two additional digits) and then randomized to intervention or control groups. The 106 intervention subjects participated in 6 hours daily of therapy, completed behaviourally enhancing assignments in the evening, and wore the restraining padded safety mitt for a target of 90% of waking hours. This has since become the traditional treatment protocol used in many future studies. A control group of 116 received 'usual and customary' care, which ranged from no treatment, orthotics, Botox, home care, day program, or outpatient hospital visits and were tracked during monthly phone

calls. Controls were also offered the CIMT program after a twelve month evaluation was completed and they became the 'delayed' treatment group. The primary outcome for motor function was the Wolf Motor Function Test (WMFT) and for functional recovery was the Motor Activity Log (MAL). The Stroke Impact Scale (SIS) was used as a secondary outcome and was completed pre-intervention and at the 4 and 12 month follow up assessments. The CIMT group demonstrated larger improvements than controls on all primary outcomes and the hand subscale of the SIS post treatment. These improvements persisted on all scales at four, eight, and twelve month follow-up periods. There was no significant difference between the lower and higher functioning groups, nor was there any moderation of treatment effect due to age, sex, or whether their affected side was their dominant hand. As a result of EXCITE, much has been learned about the effectiveness of CIMT and how we quantify and measure this.

2.5 Outcome Measures in CIMT

2.5.1 *Wolf Motor Function Test (WMFT)*

Originally developed as the Emory Motor Test, the WMFT (see Appendix B) was first used in forced use studies in the late 1980's and has since been used in over twenty studies of CIMT, including EXCITE.[4] It is a laboratory-based assessment of upper extremity performance consisting of 15 performance items and 2 strength items. It differs from other measures in that it includes both measures of impairment and disability. Tasks are arranged in order of complexity, moving from proximal to distal joints, and include such items as lifting a can,

stacking checkers, and folding a towel. Participants are rated both on time (up to 120 seconds) and on quality of movement, using a six point functional ability scale (fas). The reliability and validity have been well established in both chronic and sub-acute populations.[33] Fritz et al have established the minimal detectable change (MDC) in sub-acute participants as 0.1 for the fas and for time as 0.7 seconds.[34] In chronic participants, the MCD is .37 for fas and 4.36 seconds.[35] In recent years, the value of statistically significant changes on outcomes has been supplemented by the value of what is a meaningful change in function. [18] The minimally important clinical difference (MCID) has been estimated for the WMFT-fas in acute care as 1.0 points if the dominant is affected and 1.2 if it is the non-dominant side.[36] For chronic stroke survivors, MCID has been established as 0.2 - 0.4 points on fas and 1.5 - 2.0 seconds for time.[35]

2.5.2 *Motor Activity Log (MAL)*

The MAL (see Appendix C) was developed by Taub's research lab specifically to measure real world use of a hemiparetic upper extremity outside of the laboratory setting.[37] It is a scripted, structured interview where participants are asked to rate themselves on 30 functional activities, such as turning on a light switch, putting on socks, or washing hands. Though it is a self-rating scale, the reliability is increased by standardized instructions and demonstration video with examples for the participants to compare themselves to. Items were chosen to represent a wide range of activities and are common activities of daily living.[38] Approximately 50% of the tasks are one handed, 25% two handed, and the other

25% could be either. Participants rank themselves on two separate five point scales – amount of use (aou) and quality of movement (qom). It has been validated in chronic[37,39] and sub-acute populations.[38] Work has also been done on the practical application of MAL scores. A clinically meaningful score is defined as the level at which a patient feels their impaired arm could be used independently for functional activities.[40] For the quality of movement scale this has been established as a score ≥3. The University of Alabama at Birmingham has stated that the MCID for both aou and qom scale is 0.5, based on work done primarily with chronic participants.[13] In work with acute participants, the MCID has been set on the qom scale as 1.0 if the dominant side is affected and 1.2 if the non-dominant is affected.[36]

The rating scales for both MAL and WMFT-fas produce ordinal level data, however, in the literature both tests are most commonly analyzed using parametric statistics. There is little explanation for this other than that because these test scores are the average of multiple items scores, they begin to approximate the continuous, interval-level data. [34,64]

2.5.3 *Canadian Occupational Performance Measure* (COPM)

Based on the Canadian Model of Occupational Performance, the COPM (see Appendix D**)** is a semi-structured interview that assists participants in generating and ranking a list of activities, or occupations, which are important to them personally.[41] The five items ranked most important are then self-rated on the ten point scale for ability to perform (Performance) and satisfaction with this

performance (Satisfaction). The MCID for both scales is 2.0.[42] The COPM has been utilized in a variety of populations including CIMT.[6,43,44]

2.6 Further Contributions from the EXCITE trial

In conjunction with EXCITE a number of sub studies took place examining the effect of CIMT on other variables including quality of life, pain and fatigue, caregiver perspective of memory and behaviour changes, and survivors perception of recovery. Qualitative information regarding caregiver's perception of post stroke memory and behaviour changes highlighted the lack of understanding of the relationship between these symptoms and depression.[45] Underwood et al found no increase in pain or fatigue ratings for 32 EXCITE participants in both the early and delayed group.[46] Data from the Stroke Impact Scale (SIS) collected during EXCITE revealed that on the physical domains, poorer health related quality of life (HRQOL) was associated with age, nonwhite race, more co-morbidities, and reduced upper extremity function. For memory and thinking subscales, it was associated with more co-morbidities and for communication subscales, with ischemic stroke and concordance.[47] Fritz's work on participant perception of recovery eventually led to the establishment of clinically meaningful MAL scores.[48]

2.7 Comparison to Other Treatments of Upper Extremity Hemiparesis

A wide variety of therapies have been used in the control groups of randomized control trials of CIMT. In EXCITE, the control group had varying activities including no treatment, orthotics, Botox, home care, day program, or

outpatient hospital visits.[32] Other studies have used sessions focused on proprioceptive neuromuscular facilitation (PNF), functional task practice, stretching and compensatory techniques.[49] Several studies out of Taiwan quantified their standard therapy as neurodevelopmental techniques (NDT), functional task practice, stretching, weight bearing, fine motor activities, and compensation.[8,50] Van der lee also used NDT in his comparison of forced use therapy. [51] On the whole, CIMT was considered superior to these controls.

More recently, the merits of bilateral arm training (BAT) have been explored with some positive results.[52-55] During BAT, participants may engage in bilateral isokinematic training, mirror therapy, device driven bilateral training, or bilateral motor priming. Some programs require both arms to be engaged in the same activity simultaneously, others just that both are involved even if the activity is different. This is in direct contrast to CIMT, where use of the less affected upper extremity is strongly discouraged. As with reviews of CIMT, there are issues with lack of large, well designed studies, use of control groups, and definition of BAT. Several recent studies have directly compared CIMT to BAT. A distributed CIMT group (2 hours daily for 15 weekdays), a BAT and control group (NDT) of equal intensity were compared on motor recovery (WMFT), functional use (MAL), and kinematics.[56] Both CIMT and BAT groups demonstrated significantly greater improvements on the WMFT than controls and the CIMT group had significantly better results on MAL than either BAT or controls. From a kinematic analysis, it was found both CIMT and BAT groups had a more significant improvement in movement quality than controls but that

the BAT groups' movements were quicker and produced more force. The authors hypothesized that because it involves both hemispheres of the brain, BAT may utilize more uncrossed corticospinal pathways and recruit a larger number of motor units resulting in more force generation. They also suggest that skills developed by either CIMT or BAT can generalize to unilateral or bilateral tasks and propose an interesting rational as to why CIMT scores were higher for functional use. They state that even though many tasks in the real world are bilateral, often the hands are performing different tasks (for example, one hand grasping and one hand peeling). Because CIMT focuses on functional tasks that often require dexterity, they may capitalize more on these skills and have an added benefit over BAT, which in this study focused on more generalized symmetrical tasks such as lifting two cups, grasping two towels, or wiping the table with two hands.

A similar study compared a group receiving the restraint and functional task practices components of CIMT to a group receiving BAT, consisting of intrusive and repetitive cuing to use both hands during all activities.[44] Therapy took place 6 hours daily for 10 weekdays. Participants were stratified into a lower and higher functioning group (based on WMFT score) and evaluated on motor recovery (WMFT) and daily function (Canadian Occupational Performance Measure) immediately post and 6 months after program completion. Both groups showed significant improvement on WMFT and COPM but did not differ from each other, regardless of pre-treatment functional level. These authors propose

that the active components of intensive practice and attentional focusing are common to both therapies and responsible for the similar results.

2.8 Patient Selection in CIMT

2.8.1 *Type of Injury*

The great majority of research into CIMT has been with stroke survivors. The success of CIMT in all phases of stroke recovery has led to exploration of its application to other neurological diagnosis that cause upper extremity dysfunction. A small study of CIMT in Parkinson's disease did not demonstrate any benefits, [57] but statistical improvements in MAL and WMFT were seen with a study of six participants with slowly progressive Multiple Sclerosis.[58]. Studies of focal hand dystonia were positive but deviated significantly from standard protocols.[59] There has been widespread development of CIMT programs for children with cerebral palsy with one recent review finding large and rigorous treatment effects in several of the most rigorous studies.[60]Other than stroke, one of the most common causes of upper extremity hemiparesis in adults is traumatic brain injury. While there are a couple of studies that include both stroke and brain injured participants they were not separated for data analysis.[6,61] One group has looked at a brain injury population using the restraint component only and showed improved Purdue peg board scores.[62] Another evaluated 22 participants with chronic brain injury using the traditional CIMT protocol.[63] Motor criteria was similar to stroke studies (20° wrist extension, 10° each digit) and while cognition was screened with the Mini-mental Statue Exam (MMSE), no measure of

behavior or attention was performed. The participants showed statistically significant improvements in motor performance as measured by the Fugl-Meyer Motor Performance Assessment and WMFT and in functional use as measured by the MAL. Participants were followed for two years and though scores did decline over the follow up period, they remained significantly better than before the treatment. Adherence to mitt wear was also tracked and the participants were divided into low adherence (wore <58% of waking hours) or high adherence (>58%). While all participants improved, those with better mitt compliance had higher scores. Their scores were very similar to results of participants with stroke, whose average time of wear would be closer to 75%.[13] Factors that were thought to influence outcomes in the brain injured population included impaired cognition, less caregiver support, and higher level of ADL expectations, for example taking care of a young family or more paid employment.

2.8.2 Location of injury

The CIMT literature does not typically specify details on type and location of participant's infarcts. Only a few studies mention whether strokes were cortical versus subcortical or hemorrhagic versus ischemic stroke. [32,64-66] More specifically, the MRIs of 44 traditional CIMT participants were examined and it was found that those with corona radiata infarcts had poorer motor ability but not functional use scores prior to treatment.[67] This supports the behavioral theory that decreased function, or learned non-use, is not always directly correlated with motor function. After completion of treatment, it was found there was no

relationship between infarct location and functional or motor scores. The authors suggest these finding indicated neuroplasticity as a result of CIMT be induced irrespective of damaged motor pathways.

While studying stroke survivors with lower levels of motor function, Sterr et al used diffusion-tensor imaging (DTi) to examine infarct volume and involvement of the Cortico-spinal tract (CST).[68] They found an association between CST damage and poorer baseline motor ability No such relationship was found with infarct volume. After participation in a modified CIMT program, both motor ability and functional use improved, irrespective of either CST damage or infarct volume.

2.8.3 *Additional Factors*

In an attempt to identify which individuals might benefit the most from CIMT, a wide variety of demographic and motor criteria have been analyzed. One of the earliest studies analyzed various demographic factors including side of stroke, time since stroke, hand dominance, age, sex, and ambulatory status.[69] It was found none of the factors related to post treatment WMFT scores and only younger age related to higher MAL Scores. The same group various motor skills of 55 stroke survivors, more than six months post injury.[70] They found only finger extension at baseline was predictive of higher motor ability score on the WMFT after CIMT. These findings were replicated in 2009 by Lin et al, who examined a CIMT groups' age, sex, side of stroke, time since stroke, spasticity (Ashworth Spasticity Scale), neurological status (NIHSS score), and hand function.[71] Again,

it was found that initial hand function, as well as time since stroke, correlated with motor recovery and quality of movement on the MAL. Hand function and age correlated with amount of use on the MAL. These findings together, indicate that hand function, and specifically finger extension is the best predictor of response to CIMT and that other factors such as dominance or side of stroke are not valid exclusionary criteria. The challenge of targeting this therapy to the most appropriate participants is highlighted nicely in several articles.[72,73]

2.9 Timing of CIMT

The majority of early CIMT studies focus on stroke clients more than one year post stroke and according to Evidence Based Review of Stroke Rehabilitation the evidence for this chronic population is strong.[74] Evidence for the sub-acute population is labeled as 'effective', primarily based on evidence from the EXCITE study. Secondary analysis of the early and delayed treatment groups from EXCITE yielded more information regarding the most effective time to incorporate CIMT.[75] The early (sub-acute) treatment group, who received treatment 3-9 months post stroke had better outcomes initially post treatment than the delayed (chronic) group, who received treatment 15-21 months after their stroke. However, at reassessment 24 months after enrolment in the study, there were no significant differences between the groups, leading to the conclusion delayed treatment does not reduce the efficacy of treatment.

The greatest debate about timing of CIMT remains in the acute phase. This is based in large part on animal studies that showed early application of

forced use therapy in rodents in the first seven days post injury resulted in exacerbation of lesions and poorer motor outcomes.[76] This was later challenged when both morphological and behavioural response to skilled reaching training in rodents was compared when initiated at day 5, 14 or 30 after stroke.[77] This study found that the group that received the earliest training had not only better results on behavioural measures but showed no evidence of exacerbation of injury on histological exam.

Acute care CIMT in humans was studied in a randomized control trial comparing three hours of physical therapy to three hours of CIMT in clients within 14 days of stroke.[66] Three outcome measures were used: the Fugl-Meyer Assessment of Motor Recovery (FMA), the Motor Activity Log (MAL) and the Grooved Pegboard Test (GPT) and participants were tested immediately prior, immediately post and three to four months after the intervention. While the CIMT group did show higher scores than the physical therapy group, the improvements were not statistically significant. All participants were also examined by Transcranial Magnetic Stimulation (TMS), which showed improved motor thresholds in both groups but no significant differences between them. The authors conclude that positive results from a preliminary study [73] had led to overestimation of the effect size and inadequate sample size of 23 participants for this study. The result was an underpowered study that showed an advantageous trend of CIMT but not statistical significance. Despite this explanation, these results were replicated in a much larger study released in 2009, VECTORS.

A single-centre RCT named the Very Early Constraint Induced Movement Therapy during Stroke Rehabilitation (VECTORS) randomized 52 participants who were an average of 9.65 days post stroke, into one of three groups.[78] One group participated in two hours of CIMT (including shaping and mitt wear for six hours daily), another in three hours of daily CIMT (shaping and mitt wear 90% waking hours), and the final group was a dose matched control group (one hour ADL retraining, one hour bilateral arm training). Individual and circuit-training sessions were common for all participants. A subset of participants (two in control, four in two hour CIMT, three in three hour CIMT) also underwent MRI analysis. Outcome measures used included the Action Arm Research Test (ARAT), the Functional Independence Measure (FIM), the hand subscale of the Stroke Impact Scale (SIS), and pain and depression ratings. The study yielded interesting information regarding the dose-response relationship. Essentially, the control and the two hour CIMT groups had similar results for motor recovery (ARAT) and the three hour CIMT group had significantly poorer ARAT scores immediately post intervention. The SIS hand scale showed the control group improved the most immediately post program but the two hour CIMT group had the greatest improvements at three month follow up. Again the three hour CIMT group was significantly poorer at 90 days. There were no differences between the three groups on the FIM, pain, or depression scales. None of the participants showed any enlargement of lesion on their MRI, helping allay fears that early CIMT might exacerbate lesions in humans. This inverted dose-response relationship, with more CIMT yielding lower results, was not due to lesion

enlargement, more pain, or depression, thus it remains to be seen what the cause was. The authors hypothesized that an over training effect, such as seen in resistance training, or perhaps that the motor learning response to a more 'blocked' distribution of therapy could contribute to the lower results in the three hour group. The importance of having a dose matched control group and more investigation into dose-response therapies are highlighted by this study.

2.10 Modified CIMT (mCIMT)

One of the major barriers to more widespread application of CIMT is the intensity of labour required to implement a program.[79-81] Attempts have been made to address this by modifying or distributing the therapy by reducing the total number of treatment, providing equivalent hours of therapy over a longer time frame, or altering certain elements of the protocol. Table 2-1 summarizes important aspects of CIMT studies that used traditional, modified/distributed or group protocols.

Table 2-1: Summary of major CIMT studies

	Study	Size/ Population	Design/Protocol	Total hours treatment	Outcome Measures	Results	Comments
TRADITIONAL	Wolf et al 2006 "EXCITE"	N = 222 Sub-acute	Compared CIMT and 'usual care', 6 hours/day, 10 days	60	WMFT, MAL, Stroke Impact Scale	Improved on all and maintained gains.	Signature CIMT study, largest RCT to date
MODIFIED AND DISTRIBUTED STUDIES (INDIVIDUAL DELIVERY)	Sterr et al, 2002	N = 15 Chronic	Compared 6 hour to 3 hours daily over 10 days	60 and 30	WMFT, MAL	3 hours improved, but not as much as 6	13 stroke, 2 TBI
	Dettmers et al, 2005	n =11 Chronic	3 hours/day for 20 days	60	Stroke Impact Scale, MAL, WMFT, Frenchay Arm Test, Nine hole Peg Test	Improved on all and maintained at 6 months	Most change in first week, unsure of added benefit of two additional weeks.
	Page et al 2004	n =17 Chronic	1 hour, 3x/week for 10 weeks compared to 'regular' and 'no' therapy	30	Fugl-Meyer Assessment, Action Research Arm Test, MAL	CIMT did best	Restraint 5 hours/day for 5 day/week
	Stevenson & Thalman, 2007	n =12 Sub-acute and Chronic	4 hours/day for 10 days	40	MAL, COPM, modified box and blocks	Improved on all.	Circuit training, included stroke and TBI
GROUP STUDIES	Van der Lee et al, 1999	n =66 Chronic	Compared 'force use' to 'usual care', 6 hours/day, 10 days. Participants treated in groups of four with two staff.	60	Rehabilitation Activities Profile, Action Research Arm Test, Fugl-Meyer, MAL	Improved on Action Research Arm test and MAL	Treated in groups of 4, including group activities, exercise, housekeeping, crafts and games.
	Rijntjes et al, 2005	n=26 Chronic	6 hours/day for 10 days. Aim of study was to examine the effect of individual factors (such as handedness, sensory loss, spasticity, etc) but ½ treated individually, ½ treated within a pair	60	MAL, WMFT, Nine hole peg test, Frenchay Arm Test	No one factor predicted outcome on CIMT. Pairs did as well as those seen Individually.	Adapted task practice (shaping) alternated between participants in pairs.
	Leung , Ng, Fong, 2009	n =8 Chronic	3 hours per session x 10 sessions over 4 weeks. Group treatment with 2 groups of 4 patients each and 2 staff.	30	Action Research Arm Test, WMFT, MAL, box & blocks	Improved on all but small effect size	Treatment included group exercise, tea break, stretches

CIMT – Constraint Induced Movement Therapy, MAL – Motor Activity Log, WMFT – Wolf Motor Function Test, RCT – randomized control trial, TBI – traumatic brain injury

One study compared six hours of daily individual treatment to three hours daily using the traditional protocol in 15 subjects (13 stroke and 2 traumatic brain injury).[61] These subjects had a minimum of 20° wrist extension and were greater than 12 months post injury. The results showed significant improvement for both groups for motor outcomes (as measured by WMFT) and real world use (as measured by MAL) however there was greater effect in the six hour group. This effect persisted at the one month follow up period. These findings are interesting because the number of therapy hours in the modified group (three hours daily) was not markedly different than the actual practice time during the EXCITE trial.[82] Despite the fact participants attended therapy for six hours during EXCITE, it was determined only 3.95 hours was engaged in actual treatment. It is not know how much time participants in a three hour program actually spend engaged in active treatment.

Another modified CIMT study enrolled eleven participants who had a minimum 20° wrist extension and who were an average of 31.7 months post stroke.[64] These subjects received the same overall hours of traditional CIMT (60) but the hours were distributed over four weeks, instead of the traditional two. Results showed significant improvements in real-world use (MAL), motor activity (WMFT), strength and spasticity, and the Stroke Impact Scale's hand function, strength, ADL and mobility components. It was noted by the authors that the greatest improvement in MAL scores occurred after the first week of treatment which called into question the added value of the additional three

weeks of training. All gains from baseline were maintained at one and six months after completion of the study.

Participants with similar motor function to the above mentioned study, who were an average of 32.3 months post stroke were examined by Page et al.[49] Seven subjects received a modified CIMT program which consisted of consecutive half hours of occupational therapy (OT) and physical therapy (PT) three times a week for ten weeks, wearing the restraint five hours daily for five days a week during this time. The OT sessions predominantly focused on upper extremity shaping and PT sessions on lower-limb activities with some component on upper limb stretching related to activities of daily living. Four subjects received an equal dose of OT and PT focused on proprioceptive neuromuscular facilitation (PNF), and six received no therapy. The modified CIMT group showed significantly greater real world use (MAL) and motor function (Fugl-Meyer Assessment and Action Research Arm Test) than either of the other groups but there was no follow-up at the completion of the program.

In 2007, a retrospective case series describing a modified CIMT program in Winnipeg was published.[6] Twelve subjects who were an average of 14.6 months post stroke with enough residual motor function to pick up an empty water glass were treated for four hours per day for 10 consecutive weekdays. The training consisted of circuit training and goal specific tasks based on the Canadian Occupational Performance Measure (COPM), which was used as an outcome measure along with the MAL and modified Box and Blocks. While it should be

noted that baseline MAL amount of use scores were higher for participants in other modified CIMT studies (3.6 versus 1.2 in EXCITE and 1.9 in Dettmers work), the results indicated significant improvement over the intervention phase that was maintained at a six month follow-up. Similar significant improvements were seen with motor function (modified Box & Blocks) and client satisfaction and participation as measured by the COPM.

Despite these variations in application of CIMT, they were all delivered in a one therapist to one participant ratio and remain very labor and cost intensive. A group delivery model of mCIMT might help address these issues but to date there are few published reports on such a model.

2.11 Group CIMT

The literature contains several examples of CIMT being administered in a group format, though usually this was in the context of examining other factors and the format itself was not the focus of the studies. In an early study of forced use therapy, group treatment took place in groups of four with one or two occupational or physical therapists supervising.[51] Participants received six hours daily of group activities such as handicrafts, housekeeping and games and they were divided into a 'no restraint' and 'restraint (or forced use) group. It was found that the forced use group improved more on the Action Research Arm Test and MAL, but the MAL gains were not maintained at one year follow up.

Another study examining how individual factors might influence outcomes in a traditional CIMT program treated participants either individually or

in pairs.[83] For those treated pairwise, shaping trials were alternated between two participants with one trainer. It was found that all participants, regardless of being treated individually or in pairs, improved and seemed to motivate each other in a competitive way.

In a Swedish study, two to three patients were treated simultaneously by one therapist but the goal of the study was to evaluate the effect of mitt wear after a traditional program.[15] The program included adapted task practice, repetitive task practice, fine motor practice, strength training, sports and games. Unfortunately, there is no indication of how the adapted task practice trials were accomplished or at what intensity. The participants did show significant improvement in motor performance (measured by Modified Motor Assessment Scale and Sollerman Hand Function test) and real world use (MAL) and maintained or improved upon these gains at three months, with no additional effect from continued mitt use.

A study published in 2008 assigned patients on an inpatient rehabilitation unit to treatment with CIMT in groups of four led by an occupational and physical therapist, assisted by nursing staff.[84] It is unclear what the actual ratio of staff to participants was. The participants engaged in group activities six hours a day for ten weekdays and wore a restraint 90% of waking hours. They were compared to a control group of 'usual care' involving both upper and lower extremity training. Immediately post intervention, the CIMT group showed significantly better improvement on the WMFT and non-significant but higher scores on the MAL.

There was no improvement on the Functional Independence Measure. By six month follow up, the control group had caught up to the CIMT group leading to the conclusion that no long term effect of CIMT had been established.

Most recently, the group format was specifically studied when a modified CIMT protocol was applied to groups consisting of four individuals with two therapists supervising.[85] Two groups completed three hours of training per day for ten sessions. The treatment was distributed over four weeks and a mitt was worn for four hours each day. Some components of traditional CIMT were included, including adaptive and repetitive task practice, and home skills assignments, but non-traditional activities such as group stretching exercises and tea break were also included. All eight participants were in the chronic stage of recovery (49.3 months post injury) and were followed for one month after completion of the program. Improvements were achieved in motor function (Box & Blocks, Action Research Arm Test, WMFT, Functional Test for the Hemiplegic Upper Extremity – Hong Kong Version) and real world use (MAL). The results were maintained for the one month follow up period but the overall effect was small at .22 for the MAL amount of use scale. The authors felt this may have been due to a small sample size and it should be noted these participants had quite high motor function even prior to the study with an average WMFT score of 4.08/5. The subjective effect of working in a group was also discussed with the authors noting that the program "enabled a change in patient's attitudes and skill acquisition through modeling, peer sharing, and mutual support".

2.12 Glenrose Hospital Pilot Project

In 2007, the Glenrose Rehabilitation Hospital (GRH) ran a 12 month pilot project of a mCIMT program. The program ran four hours daily for ten consecutive work days and utilized a group format of three clients to one Occupational Therapist and one Therapy Assistant. Fifteen stroke survivors participated who were an average of 59.3 ± 14.1 years old, 12.2 ± 6.2 months post stroke, had an average amount of use of 1.8 ±1.3 (per MAL –aou) and average motor function of 5.4 ± 1.3 in the arm and 4.6 ± 0.9 in the hand (per Chedoke McMaster Stroke Assessment[86]). A variety of outcomes were collected including the MAL - aou and qom scales, Chedoke Arm and Hand Activity Inventory (CAHAI), and Canadian Occupational Performance Measure (COPM) and participants were followed for 6 months. Participants achieved minimal clinically important differences (MCID) by completion of the program on all outcomes with the exception of CAHAI, which reached that threshold by one month after the program (see Table 2-2).

Table 2-2: Glenrose Hospital pilot results

	MCID	**Baseline**	**Immediately post-program**	**1 month post**	**6 months post**
MAL (amount)	.5	1.8	3.2	3.5	3.5
MAL (quality)	.5	2.7	3.6	3.5	3.7
CAHAI	7	30.2	35.5	36.6	40.1
COPM (Satisfaction)	2	2.6	5	5.6	6.1

MCID = Minimal Clinically Important Difference, *MAL* = Motor Activity Log, *CAHAI* = Chedoke Arm and Hand Activity Inventory, *COPM* = Canadian Occupational Performance Measure

Significantly, at the beginning of the program only 27% of participants reported their amount of real world use was at a clinically meaningful level of 3 on the MAL quality scale but at 6 month follow up 80% had. Most impressively, all gains were maintained or improved upon during the follow up period and clients reported great satisfaction with the program in participant opinion surveys.

This program produced viable clinical results with excellent client satisfaction and was provided at a fraction of the cost of a traditional CIMT program. The cost for salary for one O.T. and one Therapy Assistant was approximately $2860 for three patients. Comparably, it would cost approximately $5460 to put three patients through the same program, one at a time, with treatment from one OT.

2.13 Summary

In the decades since the inception of 'forced use therapy', much research has gone into Constraint Induced Movement Therapy, making it one of the most talked about and studied therapies for upper extremity rehabilitation.[23,87] The preliminary evidence supporting its efficacy has lead to a plethora of research into repetitive task practice, dose-response relationships, mechanisms for action, and variations on delivery. Much is still to be discovered about the distribution of training, the persistence of effect and the best training methods. Despite the evidence supporting it, few programs have been developed, in part due to time constraints, concerns with cost-effectiveness, and inadequate resources.[18,79,80] A

proposed model to address some of these concerns is to deliver a modified CIMT program in a group format.

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Chapter 3: Manuscript

Group Delivery of a Modified Constraint Induced Movement Therapy (mCIMT) Program

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Abstract

Background: This study evaluated the efficacy of a modified Constraint Induced Movement Therapy (mCIMT) program delivered in a group format. *Objectives*: To determine: 1) if group mCIMT participants would show statistically significant and clinically important improvements that were maintained at three months; and 2) if the effect size of a group mCIMT program would be similar to those reported for individual mCIMT programs. *Methods:* Thirteen sub-acute or chronic stroke and two sub-acute brain injured participants attended a group mCIMT program for 3.5 hours daily for ten treatment days. The group consisted of three participants supervised by two staff. *Results:* Participants achieved statistical and clinically significant improvements in motor recovery (Wolf Motor Function Test), functional use (Motor Activity Log) and participation (Canadian Occupational Performance Measure). These improvements were maintained over a three month follow up period. The effect of group mCIMT was comparable to individualized mCIMT programs with similar protocols. *Conclusion:* Group delivery of mCIMT produces meaningful results and is a potentially effective way of extending availability of this program without placing overwhelming demands on health care resources.

Keywords: stroke rehabilitation; upper limb rehabilitation; constraint-induced therapy; group therapy; occupational therapy

Introduction

It is estimated that 80% of survivors of stroke experience acute arm weakness with only one-third achieving full recovery.[1] Constraint induced movement therapy (CIMT) is an established treatment for arm and hand weakness as a result of stroke and the Evidence-Based Review of Stroke Rehabilitation states that there is strong evidence supporting its use for individuals with some active wrist and hand movement.[2] CIMT improves function not only in the research laboratory but also in the ability to use the arm in functional or 'real world' use, which has been identified as the single most important factor in stroke survivors rating of their own recovery.[3] CIMT is an intensive treatment and traditional CIMT protocols require one to one participant to trainer ratio for six hours daily for ten treatment days over two weeks.[4] This is obviously a very time and resource expensive program; one that may not be feasible outside a research setting. [5] Subsequently, there have been studies on alternate deliveries of distributed [6,7] and modified CIMT[8-10] where total number of treatment hours were reduced, equivalent hours were extended over a longer time frame, or certain elements of the protocol were altered. Many of these programs had promising results; however, all of these variations continue to involve one to one treatment. There have been three reports of CIMT delivered in a pair or group setting, however, evaluation of the format of delivery (group) was not the primary objective of these studies and the effects were not directly analyzed. [11-13] To the best of our knowledge, only one small study has directly evaluated the effect of a

group treatment of CIMT and they reported small effect sizes for the outcomes of Wolf Motor Function Test and Motor Activity Log.[14]

The overall objective of this study was to evaluate a group approach for modified CIMT (mCIMT), where three participants attended simultaneously with one occupational therapist and one therapy assistant. We specifically assessed the effect of the group mCIMT program on the outcomes of motor recovery, functional use, and participation immediately after the program and at one and three months post program. We also wanted to know if any changes as a result of group mCIMT were similar in magnitude to those reported for mCIMT programs delivered individually. We hypothesized that: 1) following group mCIMT participants would show statistically significant and clinically important improvements on motor recovery, functional use, and participation, and that improvements would be maintained at three months; and 2) the effect size of a group mCIMT program would be similar to those reported for individual mCIMT programs.

Methods

Design

This study used a quasi-experimental, repeated measures design with assessment at five time points: baseline, immediately pre-program, immediately post-program, one month post-program and three month post program.

Recruitment/Participants

After receiving operational and ethical approval from relevant university and hospital administration, the study's principal investigator (PI) held

information sessions for therapists at local community rehabilitation clinics and rehabilitation hospital outpatient stroke/brain injury programs. Therapists identified potential candidates and obtained consent for release of information to the PI, who contacted candidates by phone for further explanation of the study and to book initial evaluations. It was made clear to all participants that involvement in the study in no way affected current or future access to rehabilitation services. All assessments for determination of eligibility were completed by the PI, who was a clinician and the coordinator of the mCIMT program at the hospital where the program was delivered. Inclusion criteria for the study included: 1) Mild to moderate upper extremity motor impairment as a result of stroke or other brain injury (Chedoke McMaster Stoke Assessment[15] score ≥4 in the arm and hand); 2) Reduced functional use of upper extremity (Motor Activity Log[16] amount of use score of ≤ 2.5); 3) At least six months post injury; 4) Able to participate in 3.5 hours of therapy daily, with short rest breaks as needed; 5) Adequate communication, perceptual, and cognitive skills to participate in self-rating scales; 6) Medically stable, including no significant joint or upper extremity pain; 7) Independent with activities of daily living, including toileting and medication administration; and 8) Not receiving Botulinum Toxin A for upper extremity spasticity.

Sample size was determined based on effect size from the Motor Activity Log during the hospital's mCIMT pilot program. The effect size was 1.46, which is large based on Cohen's guidelines (large effect being >.8, moderate effect being

>.5 and small effect being >.2).[17] Using this large effect size, the sample size required to achieve 80% power to find a difference between pre and post mCIMT was six.[18] We over sampled to allow for appropriate numbers in the groups and to compensate for any error as a result of an overpowered pilot project. If participants met the admission criteria and were interested in being enrolled, informed consent was obtained and appointments for baseline functional assessments made with the independent assessor.

Outcome Measures

A licensed Occupational Therapist (OT) trained by the PI acted as an independent rater for all assessments. To assist with standardization, training videos on the outcome measures and demonstration videos for the participants were utilized and portions of the assessments were videotaped for review by the rater. In order to establish participants were stable in motor recovery, an assessment was completed on average 10 days prior to commencing the intervention and again the Thursday or Friday prior to starting the program. Post program assessments were done within four working days of completion of the program, and repeated one and three months later. Primary outcomes were the Wolf Motor Function Test – functional ability scale [WMFT- fas] and Motor Activity Log – amount of use scale (MAL – aou). Secondary outcomes were WMFT - time, MAL – quality of movement (qom) scale, and the Canadian Occupational Performance Measure (COPM).

The WMFT, used to measure improvements in motor function, is a time based evaluation of fifteen functional and two strength based upper extremity

tasks which also provide information on joint specific and total limb movements. In addition to time, quality of movement is assessed by a 6 point Functional Activity Scale (fas). Originally validated on chronic stroke patients, [19,20] it was further evaluated with sub-acute patients during the EXCITE trial.[21] The tool has been used extensively in CIMT research and has well established reliability and validity.[22]

Functional recovery was evaluated with the MAL, a self-rating scale which was developed specifically to measure spontaneous, real-world use of weakened arms, outside of the treatment setting. [16, 23] It contains thirty commonly performed activities of daily living on which subjects rate themselves on two separate rating scales for amount of use and quality of movement, each providing a score out of five. Though it is a self-rating scale, the reliability is increased by standardized instructions and demonstration video with examples for the participants to compare themselves to. As portions of the quality of movement scale were administered daily as part of the behavioral enhancement package, it was not administered immediately pre and immediately post program. It was used at baseline, one and three month follow ups.

Finally, the COPM was utilized to measure participation or involvement in meaningful occupations. The COPM is a semi-structured interview that assists participants in generating and ranking a list of activities, or occupations, which are important to them personally.[24] For the purposes of this study, participants were instructed to focus on activities impacted by their upper extremity weakness.

The five items ranked most important are then self-rated for *performance* and *satisfaction* on a visual analogue scale from one to ten. Clinically, this tool is useful not only for rating satisfaction for activities that are valued by participants but also for assisting with identification of relevant treatment activities.

Intervention

Participants were divided into five groups of three participants each and within that group attended a mCIMT program supervised by one Occupational Therapist (OT), the PI, and one therapy assistant (TA). The first two groups took place concurrently, with one in the morning and one in the afternoon and subsequent groups took place in the morning. Within each group, participant start times were rotated (Table 3-1). The program consisted of 3.5 hours of treatment daily for 10 consecutive weekdays and included all components of the standardized CIMT protocol, including the behavioral package, repetitive, task specific training, and restraint.[25] Approximately 20% of the day was spent on behavioral enhancements, such as reviewing home dairy, discussing mitt wear, and generating home skills assignments. Another 30% of the day was engaged in shaping, or adaptive task practice (ATP), where by movement goals were approached in incremental steps, in an intensive, repetitive fashion. These components, like most traditional CIMT programs, were administered in an individualized format with the OT. The remaining 50% of the program was spent engaged in functional task practice, including activities based partially on items identified as important by participants on the COPM. During this portion of the

program, two participants were supervised by a TA simultaneously. At times they worked on individual tasks, such as writing or computer work, and other times worked on a collaborative activity, such as cooking or a game. Attempts were made to alter bilateral tasks to unilateral by modifying the activity or employing adaptive devices. When this was not possible, the TA acted as the second hand. Careful planning and consideration was given in order to minimize downtime while the TA was working with the other participant and short rest breaks were allowed as needed.

All participants wore a padded safety mitt on their less involved upper extremity while in therapy and were encouraged to wear it up to 90% of waking hours while outside of therapy. Even while not wearing the mitt, participants were strongly encouraged to think of ways to engage their more involved extremity and to avoid long periods of inactivity.

Data Analysis

Descriptive statistics, including means and standard deviations, were calculated on demographic data and outcome measures using SPSS (version 18). The number of scores that met minimal clinically important differences (MCID) and clinically meaningful scores were determined. The MCID is defined as the minimal change in score which a patient would perceive as beneficial[26] and a clinically meaningful score is the level at which a patient feels their impaired arm could be used independently for functional activities.[27] Repeated measures analyses of variance (ANOVAs) were used to determine if there were statistically

significant differences in primary and secondary outcome measures across the five time points. Though the WMFT-fas, MAL, and COPM produce ordinal level data, in this instance they were treated as interval data in order to run parametric statistics, which has been the convention in the majority of CIMT studies.[6,8,10,] Significance was set at <.05 and where differences were detected, post-hoc pair-wise comparisons with Bonferroni corrections were completed.

Results

A total of fifteen participants were recruited (Table 3-2); ten from the rehabilitation hospital outpatient stroke program, one from the rehabilitation hospital outpatient brain injury program, and four from the community rehabilitation clinic (three stroke/one brain injury). Eleven of fifteen participants were in the sub-acute phase of recovery (less than twelve months since injury) and their ages of ranged from 22-77 years. All participants had received extensive upper extremity rehabilitation prior to enrolment with twelve being former inpatients at the rehabilitation hospital. At commencement of the study all but four participants were continuing to receive some form of outpatient occupational or physical therapy, although most were at the low frequency of less than one hour per week. No upper extremity rehabilitation was received by any participant for the duration of the study. Thirteen of fifteen participants attended 100% of the treatment days. Two participants in groups one and two missed one treatment day each (one due to transportation difficulties and one due to inclement weather). Four subjects were not available for baseline assessments and their

single pre-program score was used for both time points during the repeated measures ANOVA. Follow up data was incomplete for two subjects in group four; one went on extended vacation after the one month follow up and the second unexpectedly underwent Botox injection after his immediate post-test evaluation, disqualifying him from further analysis. At the immediate post program analysis, both participants had achieved MCID on WFMT and one on MAL -aou. Data for these participants was not included in the ANOVA analysis. A third participant did not complete the COPM at three months.

Raw scores improved on all outcome measures and were maintained through the follow up period (Table 3-3, Figure 3-1). The repeated measures ANOVA showed no significant differences between the baseline and pre program assessment scores, indicating motor recovery was not fluctuating. Changes from pre to post program were statistically significant and there were no significant changes during follow up assessments. Effect sizes were moderate for primary outcomes of WMFT – fas and MAL – aou, moderate for the secondary outcomes of COPM, and small for WMFT – time and MAL – qom. Just as important, the results indicated the program had a clinical impact on participants. At completion of the study, 77% of participants achieved MCID on MAL-aou and 69% on the WMFT-fas; percentages that had continued to improve throughout the follow up period (Figure 3-2). Moreover, prior to the program 27% of participants had a clinically meaningful score of ≥3 on the MAL–qom scale but at completion of the study this had reached 54%. Another two participants achieved a score of 2.98. Had their scores been rounded up that would bring the total percentage to 70%

Discussion

CIMT is a treatment intervention with strong evidence that it improves upper extremity function.[2] However, the demands it places on personnel, space and equipment have limited its applications in a clinical setting. To mitigate these demands, the program contents, the way the hours are distributed or the way they are delivered (i.e. individual versus group) could be modified. Little is known about whether these changes dilute the overall effectiveness of the therapy. The unique aspect of our program is that it closely followed a traditional CIMT protocol of repetitive task practice, behavioral enhancement, and restraint but delivered them in a group format. Our participants demonstrated statistical and clinical improvements in motor recovery, functional use, and participation and maintained these improvements over a three month follow period. Not only were gains maintained but results continued to improve, including the percentage of participants who achieved clinically meaningful scores on the MAL. This suggests that mCIMT delivered in a group has numerical improvements as well as improvements that make a difference in the daily lives of participants.

Previously, individualized mCIMT programs (i.e. delivered one on one) have shown a wide variety of effects which is not be surprising given the large variation in components, distribution, and intensity. [28] We compared our results with two studies that also used a mCIMT protocol of 3-4 hours of treatment daily over ten days and but delivered it in a one on one format.[8, 10] (Table 3-4). They reported effect sizes of .57 and .84 for the MAL –aou, which is comparable to our

effect sizes achieved with a group approach. [8,10] These findings support our hypothesis that group delivery of mCIMT can be as effective as individual mCIMT. Unfortunately, similar protocols of individualized mCIMT have either not utilized the WMFT as an outcome or not reported effect sizes, so we are unable to compare our effect sizes for motor recovery.

To the best of our knowledge, Leung and colleagues are the only other investigators who have specifically tested the effects of a group protocol. [14] There were some key differences from our study (Table 3-4). While all components of traditional CIMT were included, the same number of hours of treatment (thirty) was distributed over four weeks instead of two. Their sample size was smaller, the population more chronic, the follow up period only one month and their ratio of participants to staff slightly lower (2:1). The effect size for both WMFT-fas and MAL-aou were small at .2 and .22 respectively compared to .56 and .75 in our study. The difference in effect size for motor function might be partially explained by the higher baseline functional levels of participants in the Leung study which left much less room for improvement for their participants. Though the MAL-aou baseline scores were quite similar to our study, our higher effect on MAL might be attributed to the more concentrated delivery of the program and emphasis on the behavioral enhancement techniques. In our clinical experience, the behavioral enhancement package is essential to facilitating the transfer of motor skills to the 'real world' and daily support and encouragement is pivotal in adoption of these practices outside of therapy.

In addition to effect sizes, Leung et al commented on the subjective effect of working in a group on the participants, noting that the program "enabled a change in patient's attitudes and skill acquisition through modeling, peer sharing, and mutual support".[14] We found similar results with participants commenting on the camaraderie, support, and inspiration in seeing how others accomplish tasks. One participant stated she wanted to do her best during collaborative activities, as not to diminish the treatment her co-participant was receiving. Though laughter and enthusiasm were often contagious, the opposite was occasionally seen with a negative attitude, particularly in regards to mitt wear. Though participants had poor compliance with recording mitt wear, subjectively we know that mitt compliance outside of the program was patchy at best. Despite this, staff continued to try to impress upon the participants that finding a way to involve the weaker hand, regardless of restraint of the stronger hand, was the key to success. To date, it remains unknown how much of the overall treatment effect of CIMT is due to the mitt but it is now generally accepted it is the least meaningful component of the program.[5] Additionally, we found it necessary to discourage participants with different levels of motor recovery from comparing themselves to each other. While it was easier logistically to schedule similar task practices concurrently, we found this was not helpful for the lower level participants and instead tried to have participants work on different elements of a collaborative task (ie. one participant gather items for cooking, the other open packages). Careful organization of activities was required at all times in order to make best use of participants capabilities, make efficient use of treatment space, and

maximize TA effectiveness. The participants gave the program very positive reviews on opinion surveys, with 100% of them agreeing or strongly agreeing with the statements "Attending CIMT in a group was a *positive* experience for me" and "The group's support helped me to improve." The variety of personalities and activities was seen as beneficial for both participants and staff and despite the clinical challenges for staff in scheduling, preparation, and intensity, they found it very rewarding to watch the participants' progress. From a purely fiscal standpoint, this program was provided at a fraction of the cost of a traditional CIMT program. The cost for salary for one OT and one Therapy Assistant was approximately $2860 for three patients. Comparably, it would cost approximately $5460 to put three patients through the same program, one at a time, with treatment from one OT. There is no doubt the group format allowed us to offer this valuable therapy to more individuals in a more economical fashion.

Limitations of this study, as with many studies of CIMT, include the small sample size, limited follow up period, self-report outcome measures, and lack of a control group. Budgetary limitations as well as clinical practicality influenced the length of time the study could run and though seemingly small, sample size was determined by appropriate power calculations. Two of the outcome measures utilized were self report measures and though they have proven reliability and validity,[16,24] the possibility of a placebo effect cannot be ruled out. Nonetheless, MAL is a primary outcome measure in the majority of CIMT studies and it was important to use in order to allow comparisons with existing literature. The biggest weakness of the study is the lack of a control group. This program was

delivered in a clinic setting with the intent to evaluate the effectiveness and practicality of such a program. The resources required to run a control group were impractical in terms of staffing and treatment space. In lieu of a control group, we have compared our results with other studies with the most similar populations and protocols. However, conditions were not identical and therefore conclusions regarding comparison of effect sizes between studies must be treated with caution. Despite these limitations, the success of this study encourages ongoing investigation of whether additional modification of the traditional protocol will yield further positive results.

Given that small group treatment was effective, the question arises of whether even larger groups would be possible. While this concept is worth investigating, the format would need to be carefully considered. One major limitation is that in order to maintain the intense level of treatment offered in an evidence-based CIMT program, some element of adapted task practice (ATP*)* should be incorporated. The amount of time spent in ATP in major CIMT studies can be as much as 50% and in this study was approximately 30%. [29] It is not known how much ATP can be reduced without diminishing the effectiveness of the treatment. Alternate modes of delivering ATP have been trialed with one study of six hours per day CIMT delivering it in pairs with participants trained alternately by one therapist.[12] No differences were reported between participants receiving individual or pair wise treatment but as the total hours of treatment was double that in our study, it is not possible to compare intensity of training.

Another option might be to increase the number of participants during repetitive task practices, such as in circuit training or a generalized upper extremity strengthening class. Unfortunately, the unilateral nature of the tasks in CIMT requires more hands on assistance from staff which might not be feasible in larger groups. Additionally, in this study we attempted to tailor task practice to activities that were meaningful to individual participants in an effort to facilitate carry over outside of clinic. In our clinical experience, keeping individuals with diverse backgrounds and interests engaged in therapeutic activities over thirty-five hours requires a great deal of creativity which might be lacking in more generalized training. More collaborative activities or group projects could be attempted but group dynamics, participant personalities and functional abilities would have to be carefully coordinated.

Finally, some components of behavioral enhancement could be carried out as a group discussion. While the more public format might discourage some participants from sharing as openly, the opposite might also be true with brain storming and peer support enhancing the experience in a way individualized support from the therapist does not. Ultimately, if any element of individualized, intense, treatment is to be included in a group format, it is likely the maximum number of participants would need to be capped at four to five. More studies of the intensity of group training, role of group dynamics, and the qualitative experiences of participants are warranted.

The establishment of CIMT programs in a clinical setting has remained limited and modifications to the original protocol have been made in order to facilitate more widespread development of programs. As more is discovered about the contribution of individual elements of the protocol, intensity of treatment and ultimate distribution of the program, the overall effectiveness of the program must be continuously evaluated. We found that delivery of a mCIMT in a group setting resulted in statistical and clinical improvements in motor recovery, functional use and participation for sub-acute and chronic stroke survivors. The effect of group mCIMT was comparable to individualized mCIMT of similar protocols. Both therapists and participants report the experience was positive and that they did not feel the group format diminished their success in the program. We propose that group delivery of mCIMT can be an effective way of extending availability of this program without placing overwhelming demands on hospital resources.

Acknowledgements: This work was supported by a grant from the Glenrose Rehabilitation Hospital Foundation Clinical Research Fund and the first author was supported in part by a scholarship from the University of Alberta, Faculty of Graduate Studies and Research. We would like to thank the Occupational Therapy Service and Outpatient Stroke Program at the Glenrose Hospital, particularly Linda Cameron and Rhondda Jones.

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Appendix A: Tables and Figures

Table 3-1: Sample schedule for group mCIMT

	Subject 1	Subject 2	Subject 3
8:15	Behavior Package with OT		
8:30	Task Practice 1 with TA	Behavior Package with OT	
8:45		Task Practice 1 with TA	Behavioral Package with OT
9:00	ATP with OT		Task Practice 1 with TA
9:15		Task Practice 2 with TA	
9:30			Task Practice 2 with TA
9:45	Task Practice 2 with TA	ATP with OT	
10:00			Task Practice 3 with TA
10:15	Task Practice 3 with TA		
10:30		Task Practice 3 with TA	ATP with OT
10:45	Task Practice 4 with TA		
11:00		Task Practice 4 with TA	
11:15			Task Practice 4 with TA
11:30	Behavior Package with OT		
11:45		Behavior Package with OT	
12:00			Behavior Package

ATP – Adapted Task Practice, OT – Occupational Therapist, TA – Therapy Assistant

Table 3-2: Demographic and Clinical Characteristics

Characteristic	Value
Age , mean ± SD (years)	57.07 ± 18.33
Sex, n (%) male	11 (73)
Diagnoses, n (%) stroke	13 (87)
Time post injury, mean ± SD (months)	12.33 ± 11.84
Side of stroke, n (%) right	6 (40)
Hand dominance, pre-injury, n (%) right	14 (93)
CMSA - arm, mean ± SD	4.87 ± 1.25
CMSA – hand, mean ± SD	4.47 ± 0.64
MAL – aou, mean ± SD	1.85 ± 1.08

Table 3-3: Outcome means, significance, and effect size over five time points

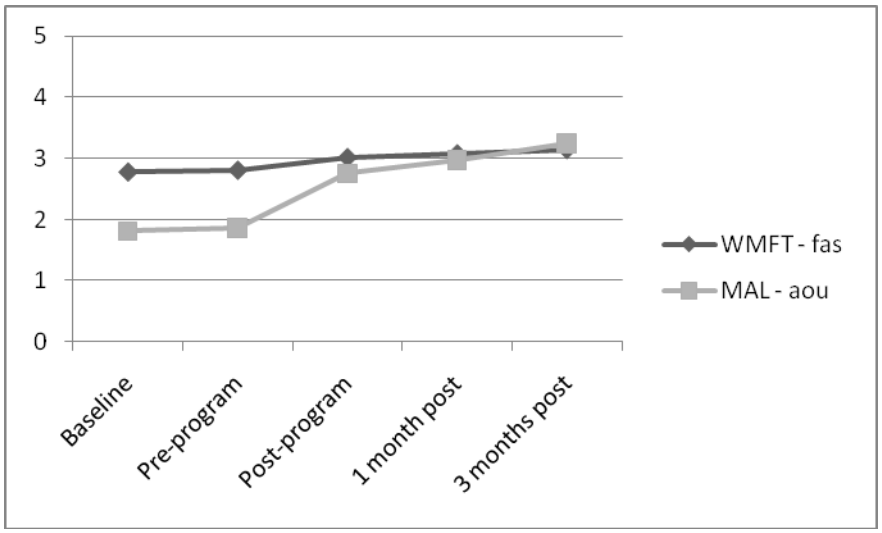
	Baseline	**Pre-program**	**Post-program**	**1 month post**	**3 month post**	**F-value**	**Effect size**
Sample Size	n = 11	n = 15	n = 15	n = 14	n = 13	n=13	n=13
WMFT-fas	2.78 (0.5)	2.81 (.5)	3.02 (.45)	3.08 (49)	3.15 (.44)	16*	0.571
MAL-aou	1.82 (1.09)	1.87 (1.06)	2.76 (1.03)	2.98 (.98)	3.16 (1.01)	30.6*	0.72
MAL-qom	n/a	2.51 (.75)	n/a	3.04 (.86)	3.28 (.81)	12*	0.5
WMFT-time	14.35 (10.1)	13.22 (8.65)	7.33 (4.73)	8.28 (6.06)	6.32 (4.32)	7.24*	0.376
COPM-perf	3.09 (1.49)	3.28 (1.35)	4.57 (1.57)	4.93 (1.7)	5.37 (1.75)	22.5*†	0.66
COPM-sat	2.99 (1.81)	2.97 (1.61)	4.48 (1.75)	4.79 (2.0)	5.08 (2.09)	20.4*†	0.65

Scores expressed as mean (standard deviation)
WMFT = Wolf Motor Function Test, fas = functional ability scale, MAL = Motor Activity Log, aou = amount of use, qom = quality of movement, COPM = Canadian Occupational Performance Measure, perf = performance, sat = satisfaction, n/a = not applicable.
*$p < 0.05$, †n = 12

Table 3-4: Comparison of individual mCIMT and group mCIMT

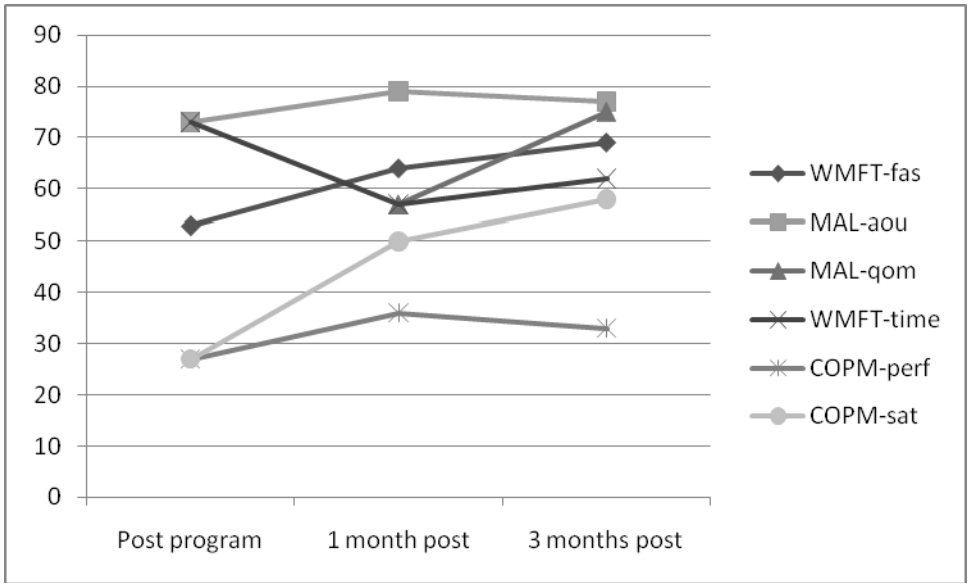
Study	**Sample Size**	**Time post event,** mean± SD (years)	**Age,** mean± SD (years)	**Protocol**	**Baseline MAL-aou**	**Baseline WMFT-fas**	**Baseline CMSA (arm:hand)**
Sterr, et al	15	4.8± 4.7	68.4±7.0	3 hr/day x 10 sessions over 2 weeks – Individual	2.0	Not reported	Not applicable
Stevenson & Thalman	12	1.22±1.85	63.25±11.89	4 hr/day x 10 sessions over 2 weeks – Individual	3.06±0.91	Not applicable	4.41±.079: 4.5±0.9
Leung, Ng, & Fong	8	4.1±2.63	58.38±7.27	3hr/session x 10 sessions over 4 weeks – Group	1.99±1.39	4.08±0.87	Not applicable
Henderson	15	1.03±.99	57.07±18.33	3.5 hr/day x 10 sessions over 2 weeks - Group	1.87±1.06	3.08±0.45	4.87±1.25: 4.47±0.64

SD – Standard Deviation, MAL – Motor Activity Log, aou – amount of use CMSA – Chedoke McMaster Stroke Assessment, WMFT – Wolf Motor Function Test, fas – functional ability scale, hr - hours



WMFT = Wolf Motor Function Test, fas = functional ability scale, MAL = Motor Activity Log, aou = amount of use

Figure 3-1: Wolf Motor Function Test, functional ability scale and Motor Activity Log – amount of use scale scores over five time points



WMFT = Wolf Motor Function Test, fas = functional ability scale, MAL = Motor Activity Log, aou = amount of use, qom = quality of movement, COPM = Canadian Occupational Performance Measure, perf = performance, sat = satisfaction

Figure 3-2: Percentage of participants achieving Minimal Clinically Important Difference (MCID) over follow up period

Chapter 4: Conclusion and General Discussion

Constraint Induced Movement Therapy (CIMT) is a proven treatment for upper extremity hemiparesis as a result of brain injury with the evidence supporting meaningful functional gains can be achieved in sub-acute and chronic populations.[1] However, the stressors it places on personnel, space and equipment have limited its applications in a clinical setting.[2,3] Various approaches to mitigate these demands have been explored including modification of the contents, the distribution, or the delivery of the program but it is not known if these changes dilute the overall effectiveness of the therapy. Previously, distributed and modified CIMT (mCIMT) programs have shown a wide variety of effects which is not be surprising given the large variation in components, distribution, and intensity. [4] In addition, the practicality of individualized training has been questioned.[5,6] To our knowledge, only one other program has directly studied the effect of non-individualized or group training for chronic stroke survivors and they found significant but small effects.[7] The unique aspect of our program is that it closely followed a traditional CIMT protocol of repetitive task practice, behavioral enhancement, and restraint but delivered them in a group format with three participants and two staff members. Our participants included both stroke and brain injury survivors in the sub-acute and chronic stages of recovery with mild to moderate impairment of their affected upper extremity. After participation in our program, participants demonstrated statistical and clinical improvements in motor recovery, functional use, and participation and maintained these improvements over a three month follow period. There was a moderate

effect size for primary outcomes and results continued to improve throughout the follow up period, including the percentage of participants who achieved clinically meaningful scores on measures of real world use. The magnitude of the effect seen with our program was comparable to similar programs of individualized mCIMT leading us to the conclusion that group CIMT may be an effective way of extending availability of this program without placing overwhelming demands on hospital resources.

The challenge of modifying CIMT to make it more clinically viable while maintaining the significant and relevant improvements in function remains. Research continues on the dosing and intensity of a variety of upper extremity therapies and more research into the training methods of adaptive and repetitive task practice is needed. As these results become available, they will need to be incorporated into further studies of group CIMT to determine the critical group size, program duration, and content. In addition, the positive and negative effects and qualitative experiences of participating in a group should be more carefully examined. Our study included both stroke and brain injury survivors, the later a group which has been infrequently studied. The effect of a group setting on participants with potentially greater difficulties with attention, cognition and/or behavior should be considered in future studies.

In conclusion, this study has attempted to address some of the challenges of implementing mCIMT in a clinical setting by delivering it in a group format, thereby making it available to more individuals with the same amount of health

care resources. We were able to show that in this population, a group mCIMT program can produce positive results while still providing a positive experience for participants and staff.

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List of Appendices

Appendix A: University of Alberta Health Research Ethics Approval

Approval Form

Date:	February 12, 2010
Principal Investigator:	Patricia Manns
Study ID:	Pro00011754
Study Title:	Alternate Delivery of a modified Constraint Induced Movement Therapy Program
Approval Expiry Date:	February 11, 2011
Sponsor/Funding Agency:	1/2/10 1/2/10 ID00000959 Glenrose Hospital Foundation Research Fund

Thank you for submitting the above study to the Health Research Ethics Board - Health Panel . Your application, along with revisions submitted February 10th and 12th, 2010, has been reviewed and approved on behalf of the committee.

The Research Ethics Board assessed all matters required by section 50(1)(a) of the Health Information Act. Subject consent for access to identifiable health information is required for the research described in the ethics application, and appropriate procedures for such consent have been approved by the REB Panel. In order to comply with the Health Information Act, a copy of the approval form is being sent to the Office of the Information and Privacy Commissioner.

A renewal report must be submitted next year prior to the expiry of this approval if your study still requires ethics approval. If you do not renew on or before the renewal expiry date, you will have to re-submit an ethics application.

Approval by the Health Research Ethics Board does not encompass authorization to access the patients, staff or resources of Alberta Health Services or other local health care institutions for the purposes of the research. Enquiries regarding Alberta Health Services administrative approval, and operational approval for areas impacted by the research, should be directed to the Alberta Health Services Regional Research Administration office, #1800 College Plaza, phone (780) 407-6041.
Sincerely,

Glenn Griener, Ph.D.
Chair, Health Research Ethics Board - Health Panel

Note: This correspondence includes an electronic signature (validation and approval via an online system).

Appendix B: Wolf Motor Function Test

Scoring definitions: **0** = Does not attempt, **1**= UE being tested does not participate functionally, **2** = Does participate but requires assistance of the UE not being tested for minor readjustments or change of position or requires more than 2 attempts to complete, or very slow, **3** = Does participate but movement influenced by synergy or slow or with effort, **4** = Does but movement is slightly slower, lacks precision, fine coordination or fluidity, **5** = Movement appears normal.

WOLF MOTOR FUNCTION TEST
DATA COLLECTION FORM

Subject's Name: _____ Date: _____

Test (check one): Pre-treatment ____ Post-treatment ____ Follow-up ____

Arm tested (check one): More-affected ____ Less-affected ____

	Task	Time	Functional Ability	Comment
1.	Forearm to table (side)		0 1 2 3 4 5	
2.	Forearm to box (side)		0 1 2 3 4 5	
3.	Extend elbow (side)		0 1 2 3 4 5	
4.	Extend elbow (weight)		0 1 2 3 4 5	
5.	Hand to table (front)		0 1 2 3 4 5	
6.	Hand to box (front)		0 1 2 3 4 5	
7.	Weight to box		_____ lbs.	
8.	Reach and retrieve		0 1 2 3 4 5	
9.	Lift can		0 1 2 3 4 5	
10.	Lift pencil		0 1 2 3 4 5	
11.	Lift paper clip		0 1 2 3 4 5	
12.	Stack checkers		0 1 2 3 4 5	
13.	Flip cards		0 1 2 3 4 5	
14.	Grip strength		_____ kgs.	
15.	Turn key in lock		0 1 2 3 4 5	
16.	Fold towel		0 1 2 3 4 5	
17.	Lift basket		0 1 2 3 4 5	

Revision date 11/29/00

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Appendix C – Excerpt from Motor Activity Log

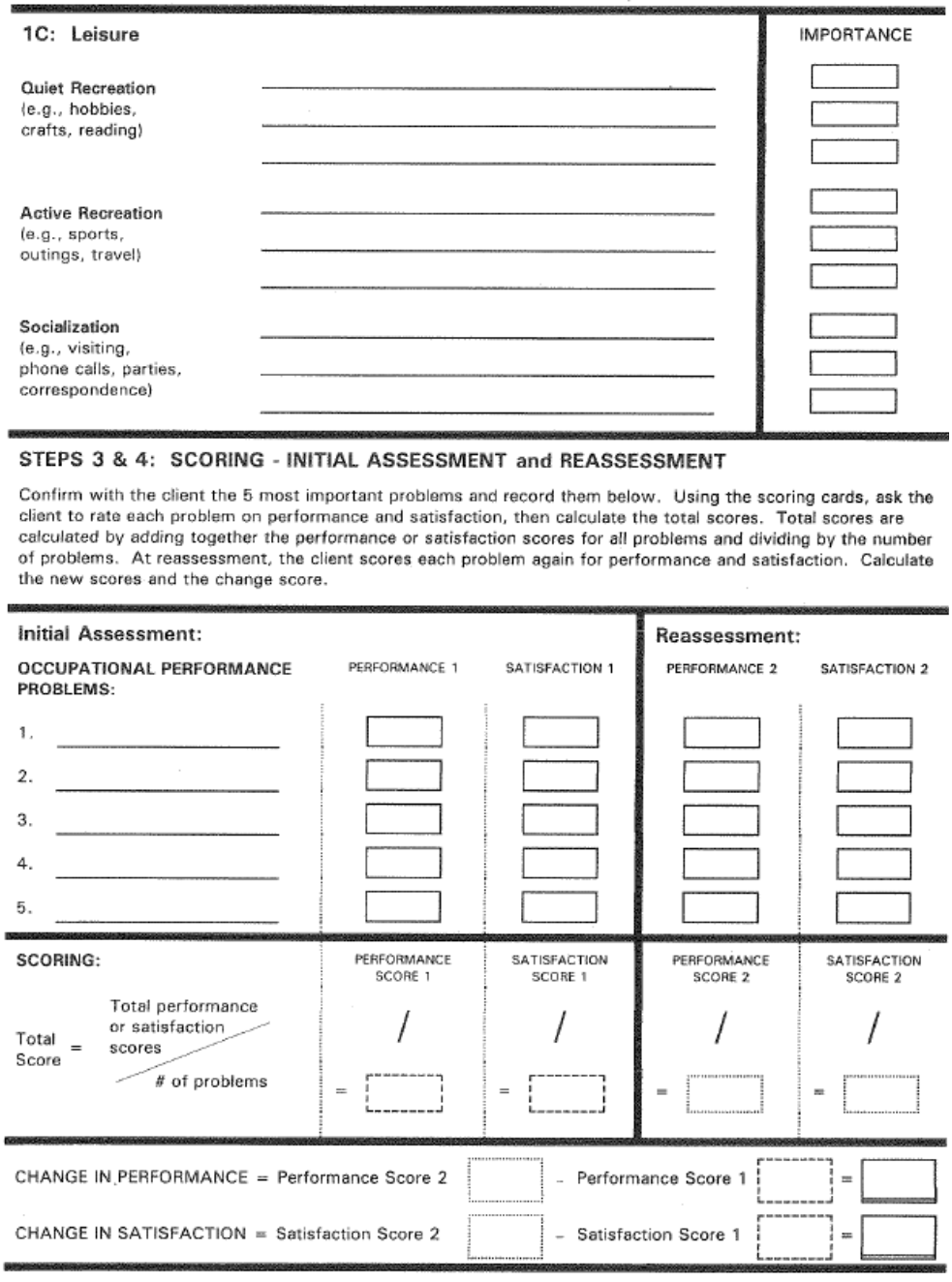
Scoring definitions (Amount Scale): 0 = Does not use weaker arm, 1 = Very rarely, 2= Rarely, 3 = Half as much as before stroke, 4 = ¾ as much as before stroke, 5 = Same as before stroke.

Name:_____ Date:_____ Examiner:_____

30 Item Motor Activity Log (UE MAL)

	Amount Scale	How Well Scale	
1. Turn on light with a light switch.	____	____	if no, why? Comments:
2. Open drawer.	____	____	if no, why? Comments:
3. Remove an item of clothing from. a drawer.	____	____	if no, why? Comments:
4. Pick up a phone.	____	____	if no, why? Comments:
5. Wipe off a kitchen counter of other surface.	____	____	if no, why? Comments:
6. Get out of a car. *(includes only the movement needed to get body from sitting to standing outside of the car, once the door is open).*	____	____	if no, why? Comments:
7. Open refrigerator.	____	____	if no, why? Comments:
8. Open a door by turning a knob/handle.	____	____	if no, why? Comments:
9. Use a TV remote control.	____	____	if no, why? Comments:
10. Wash your hands. (*includes lathering and rinsing hands; does not include turning water on and off with a faucet handle.)*	____	____	if no, why? Comments:
11. Turn water on/off with knob/lever on faucet.	____	____	if no, why? Comments:
12. Dry your hands.	____	____	if no, why? Comments:
13. Put on socks.	____	____	if no, why? Comments:
14. Take off socks.	____	____	if no, why? Comments:

Appendix D: Excerpt from the Canadian Occupational Performance Measure



1C: Leisure

IMPORTANCE

Quiet Recreation (e.g., hobbies, crafts, reading)

Active Recreation (e.g., sports, outings, travel)

Socialization (e.g., visiting, phone calls, parties, correspondence)

STEPS 3 & 4: SCORING - INITIAL ASSESSMENT and REASSESSMENT

Confirm with the client the 5 most important problems and record them below. Using the scoring cards, ask the client to rate each problem on performance and satisfaction, then calculate the total scores. Total scores are calculated by adding together the performance or satisfaction scores for all problems and dividing by the number of problems. At reassessment, the client scores each problem again for performance and satisfaction. Calculate the new scores and the change score.

Initial Assessment:			Reassessment:	
OCCUPATIONAL PERFORMANCE PROBLEMS:	PERFORMANCE 1	SATISFACTION 1	PERFORMANCE 2	SATISFACTION 2
1.				
2.				
3.				
4.				
5.				
SCORING:	PERFORMANCE SCORE 1	SATISFACTION SCORE 1	PERFORMANCE SCORE 2	SATISFACTION SCORE 2
Total Score = Total performance or satisfaction scores / # of problems	/ =	/ =	/ =	/ =

CHANGE IN PERFORMANCE = Performance Score 2 – Performance Score 1 =

CHANGE IN SATISFACTION = Satisfaction Score 2 – Satisfaction Score 1 =

Appendix E: Permission to use figures 2-1 and 2-2

Date: Tue, 18 Jan 2011 13:08:33 -0600 [01/18/11 12:08:33 MST]

From: "Edward Taub" <etaub@uab.edu>

To: cahender@ualberta.ca

Subject: RE: Reprint request

Dear Cherie Henderson, BScOT,

Thank you so much for your good opinion of our workshop and that you have set up a CI therapy program in your clinic. I hope you don't mind if I send a copy of your letter to David Morris. I am sure he will be delighted to see it.

You are of course welcome to use the two diagrams you mention in your thesis.

With my best regards,

Edward Taub, Ph.D.
University Professor
Director, CI Therapy Research Group and
Taub Training Clinic
Department of Psychology
1530 3rd Avenue South, CPM 712
University of Alabama at Birmingham
Birmingham, AL 35294-0018
Phone: (205) 934-2471 Fax: (205) 975-6140
-----Original Message-----
From: cahender@ualberta.ca [mailto:cahender@ualberta.ca]
Sent: Sunday, January 16, 2011 4:40 PM
To: Edward Taub
Subject: Reprint request

Good afternoon Dr. Taub,

My name is Cherie Henderson and I am an OT in Edmonton, Canada. I was fortunate enough to have attended your Research group's CI training course back in May of 2007 and have gone on not only to implement a CI program at my clinic, but also to pursue my master's studying CI. (We did a modified CI group with 3 patients, one OT and one assistant).
As such, I am now writing up my thesis and would like permission to include a couple of schematics from the training manual provided in the course. Specifically, "Schematic model for development of learned non-use" and "Schematic model of mechanism for overcoming learned non-use". Of course, they also appeared in your "The learned nonuse phenomenon: implications for rehab" and likely a few other articles. I found the training course so helpful in development of my program and for encouraging me to develop my skills as a researcher and hopefully contribute to this amazing body of knowledge. Thank you for your help.

Cherie Henderson, BScOT
University of Alberta
Edmonton, Alberta, Canada