The Effects of Constraint Induced Movement Therapy (CIMT) and Hand Function

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Abstract

PURPOSE: The purpose of this study was to examine the effectiveness of modified CIMT and CIMT on hand function among persons with hemiparesis surgical post CVA.

METHOD: A two phase, mixed methods approach, consisting of both qualitative and quantitative approaches, was utilized to examine the impact of stroke on hand function. Four subjects were placed in a mCIMT program and four in a CIMT program. Seven pre- to post- test scores on the WOLF were used to analyze the participants hand function.

RESULTS: The results could not be tested for statistical significance due to small sample size. However, descriptive statistics revealed that both the CIMT and mCIMT resulted in improved hand function on the seven WOLF motor subtests used in this study.

CONCLUSION: Modified CIMT and CIMT are effective treatment methods for improving hand function in persons who have experienced a stroke. Further research is needed to support these outcomes.
The Effects of Constraint Induced Movement Therapy (CIMT) and Hand Function

Cerebrovascular accidents (CVA), or strokes, are the third leading cause of death in the United States. Approximately 160,000 people die each year as a result of a CVA. Depending on the severity of the stroke, resulting disabilities can range from profound loss of function to subtle, almost unnoticeable deficits (Jamison & Orhamian, 2007). Strokes typically produce some level of weakness or paralysis in the body’s extremities and can lead to a variety of motor deficits, making activities of daily living difficult to manage (Gardersdottir & Kaplan, 2002). These deficits can be seen in gross motor movements involving the whole arm and/or fine motor movements involving the hand. Rehabilitative therapy, such as occupational therapy, is often used to improve upper extremity movements to facilitate occupational performance.

CIMT is a form of therapy that aims to overcome forced nonuse by retraining the affected extremity. CIMT uses neurorehabilitation and motor recovery techniques as the therapy invention, while constraining the non-affected upper extremity. The CIMT techniques use repetition with the affected extremity to improve motor recovery and functional performance in the affected extremity.

As explained by Runyan (2006), one traditional treatment approach for a person who has experienced a CVA is the use of neurodevelopmental treatment (NDT). Treatment involves using the right amount of physical handling to promote movement of the affected limbs, using visual and verbal cues. Key points of control are used to facilitate the hypotonic muscle groups. Therapy begins in a proximal to distal direction meaning the core muscles of the trunk are stimulated and facilitated first, before working on the more distal muscles groups of extremities. This is performed through passive and self range of motion involving specific planes of movement. As tone begins to increase, table top activities are added to the treatment program to
incorporate functional movement patterns. Reflex inhibiting patterns are also implemented to decrease tone in other muscle groups that may have become hypertonic. The goal of therapy is to normalize tone and strength imbalances between specific muscle groups (2006).

**Research Problem**

Efficient hand function is necessary for occupational performance. Much of the literature to date supports the effectiveness of CIMT in increasing gross motor function in the affected extremity (Porter & Lord, 2004). However, there appears to be a lack of clinical research exploring the effects of CIMT on individuals as it specifically relates to fine motor function.

**Purpose of the Study**

The purpose of this two-phase; sequential, mixed methods study was to obtain quantitative and qualitative information regarding the effects of CIMT and mCIMT on hand function.

**Research Question and Hypotheses**

The research questions and hypotheses that were addressed in this study were as follows:

Research Question One: Is a standard CIMT program effective in improving hand function among persons who experienced upper extremity hemiparesis surgical post CVA?

**Hypotheses to be tested:** The null and alternative hypotheses for this study were:

1. **Null Hypothesis:** There is no significant difference in pre- to post intervention Wolf Motor Function scores among participants who received a standard CIMT program.

   **H_0:** \( \mu_1 = \mu_2 \), where

   \( \mu_1 = \) Wolf Motor pretest scores

   \( \mu_2 = \) Wolf Motor posttest scores
1. Alternative Hypothesis: There is a significant difference in pre-to post intervention Wolf Motor Function scores between groups that received the standard CIMT program.

Research Question Two: Is a modified CIMT program effective in improving hand function among persons who experienced upper extremity hemiparesis surgical post CVA?

_Hypotheses to be tested:_ The null and alternative hypotheses for this study were:

1. Null Hypothesis: There is no significant difference in pre-to post intervention Wolf Motor Function scores among participants who received a modified CIMT program.

2. Alternative Hypothesis: There is a significant difference in pre-to post intervention Wolf Motor Function scores between groups that received the modified CIMT program.

**Hypotheses to be tested:**

\[ H_0: \mu_1 = \mu_2 \]

\[ H_A: \mu_1 \neq \mu_2 \]

\( \mu_1 = \) Wolf Motor pretest scores

\( \mu_2 = \) Wolf Motor posttest scores

**Definition of Terms**

*Activities of Daily Living (ADLs).* Activities that are oriented toward taking care of one’s own body (AOTA, 2002).

*Cerebrovascular Accident (CVA).* A blockage or hemorrhage of a blood vessel in the brain leading to an inadequate supply of oxygen. CVA may result in symptoms including weakness, paralysis, and speech deficits (Hanson & Atchison, 2000).

*Constraint induced movement therapy (CIMT).* An approach to stroke rehabilitation involving use of a constraint on the non-affected extremity for two weeks, five days a week, six
hours a day. It is primarily used to increase the functional use of the involved upper extremity (UE) after a stroke by constraining the unaffected limb, ultimately returning functional ability to the involved UE through forced use of the limb (Taub & Uswatte, 2006).

*Hemiparesis.* Weakness that affects one side of the body (Hanson & Atchison, 2000).

*Hypertonic.* An increased tension of the muscle meaning the muscle tone is abnormally rigid impeding normal movement (Krakauer, 2006).

*Hypotonic.* A decreased tension of the muscle meaning the muscle tone is abnormally low impeding normal movement (Krakauer, 2006).

_Modified constraint induced movement therapy (mCIMT)._ A modified version of CIMT that involves four weeks of therapy, three hours a day, five days a week instead of the standard two weeks, six hours a day, five days a week program (Page & Levine, 2007).

_Occupational Performance._ The ability to carry out activities of daily life (AOTA, 2002).

**Significance of the Study**

Constraint-induced movement therapy (CIMT/mCIMT) has been shown to improve motor ability and functional use of the involved upper extremity (Bonifer, Anderson, & Arciniegas, 2005). However, there is limited support for its effectiveness in terms of improving hand function. The results of this study will contribute to the body of knowledge of CIMT, hand function and functional performance

**Review of the Literature**

This review of literature will discuss key issues related to CIMT, mCIMT, and their effectiveness as stroke rehabilitation programs. First, the importance of hand function in ADL and occupational performance will be outlined. Next, the concept of learned non-use will be discussed. Then, traditional CIMT programs and mCIMT will be reviewed. Lastly, evidence
supporting the use of CIMT and mCIMT for improving general upper limb function will be presented.

**Role of Hand Function in ADL and Occupational Performance**

A common consequence of a CVA is a loss of motor function to some or all parts of the upper extremity, including the hand. This damage can occur from CVA-induced lesions to parts of the brain, such as the motor and sensory cortex, which impact functional use of the hand (Goulding, 2004).

Functional use of the hand is pertinent to many areas of occupational performance in activities of daily living. The hands are used to complete a wide range of tasks such as dressing, feeding, bathing, self-care, toileting, cooking, driving, work, leisure activities, and play. Both motor loss and sensory loss can result in hand dysfunction that can impact task performance. Sensory loss can be defined as a loss of touch, pain, temperature, and proprioceptive input. Motor loss results in impairment of movements of the hand such as digital flexion/extension, wrist flexion/extension, and wrist pronation/supination. When these functional losses occur in the hand after a CVA, occupational performance may decline (Goulding, 2004).

**Learned Non-Use**

Learned nonuse is a phenomenon in which “the individual effectively forgets to use the affected, or involved extremity because of extreme difficulty coordinating movement after the onset of stroke” (Phipps & Roberts, 2006). This phenomenon was first noted in the 1950’s by Taub, following research involving rhesus monkeys. Taub’s experiments involved deafferentation of one of the monkeys’ forelimbs, which involves eliminating the sensory function of the upper extremity. The monkeys had unrestricted motor capability in their affected limb, but lacked sensation in the extremity. As a result, the monkeys failed to use their affected
extremity, despite the fact that the limb had full motor capabilities. The animals’ brains appeared to disregard the affected limb because of resultant cortical changes. Taub’s experiment ultimately showed that when one of the forelimbs was deafferentated, it was not used by the animals in everyday activities. This nonuse was inadvertently reinforced by the brain, resulting in continued suppression of upper extremity use.

This learned nonuse phenomenon can be extended to humans who have sustained trauma, such as a stroke, to the central nervous system. Evidence shows that constraining the unaffected extremity and forcing the individual to use the “bad” limb can be affective in reversing learned nonuse (Pendleton & Schulz-Krohn, 2006).

**Constraint Induced Movement Therapy**

Constraint-induced movement therapy (CIMT) is a therapeutic program designed reverse learned nonuse of the affected limb for post stroke patients. The program aims to force use of the patient’s affected upper extremity by constraining the non affected limb with some type of constraint. The goal of CIMT is to improve the functional use of the affected upper extremity through intense therapy (Fritz, George, Wolf, & Light, 2007). Participants in this protocol receive two weeks of skilled therapy services for five days a week, six hours a day. They are also instructed to wear the constraint at home 90% of their waking hours when not receiving therapy services to further promote increased functional use of the involved extremity.

The traditional CIMT program can be modified to accommodate patients who cannot tolerate the rigor of the traditional program (Page & Levine, 2007). This program, known as modified CIMT (mCIMT), involves four weeks, five days a week, three hours a day of intense therapy instead of six hours, required with CIMT. Additionally, the at home restraint requirements are reduced to the top five hours of arm use. Modified CIMT may be more realistic
for someone who is unable or unwilling to dedicate six hours a day, for two weeks, to a therapy program, such as someone with diminished physical abilities, co-morbidities, or lack of good family support. In both the modified and traditional CIMT protocols, participants receive the same amount of skilled therapy (60 hours) (Page & Levine, 2007).

*Components of CIMT*

*Behavioral Training and Shaping.* In the context of CIMT and mCIMT, shaping is a process that reinforces the use of the affected extremity and combats the learned nonuse phenomenon, to help an individual reach a desired outcome. In shaping, daily tasks that are routine to the individual and relevant to their deficits are selected to be performed, primarily using the affected upper extremity. Taub defined shaping as 1.) selecting tasks that were tailored to address the motor deficits of the individual patient, 2.) helping patients carry out parts of a movement sequence if they are incapable of completing the movement on their own at first, and 3.) providing explicit verbal feedback and verbal reward for small improvements in task performance (Taub, as cited in Thorne, 2009). Multiple repetitions, of selected tasks, are performed using the impaired extremity. Positive reinforcement is provided, by the therapist, in order to help the individual relate quality movements by the impaired extremity within the selected task to meaningful occupations performed in their daily life.

*Chaining.* The goal of therapy is to build a series or chain of behaviors. A behavior chain is a series of related behaviors, with the previous providing the cue for the next. Chaining is the reinforcement of successive behaviors that are used to complete a specific skill, such as putting on a shirt (Thorne, 2009). In CIMT, basic quality movement is first established, and then more complex movement patterns are developed, ultimately resulting in successful performance of meaningful tasks.
**Massed Practice.** One of the major principles of motor learning theory is massed practice. Massed practice implies that the degree of skill improvement is dependent on the amount of repetitions that a person is able to achieve. The goal of CIMT is to improve the balance between the group I muscles (flexors, internal rotators and adductors) and group II muscles (extensors, external rotators, and abductors) of a client affected by a CVA. A person who has sustained a CVA will typically develop an imbalance between these two muscle groups, with the group I muscles becoming hypertonic and over dominating the group IIs in a flexor synergy pattern. Massed practice in therapy is aimed at increasing the tone of the group II muscles to restore balance (Krakauer, 2006). In the context of CIMT, this is accomplished by having the client perform table top activities that promote movements that cause the group II muscles to actively contract.

**Effects of CIMT and mCIMT on Upper Limb Function**

There is a lot of evidence supporting the use of CIMT and mCIMT in stroke rehabilitation. After extensive research, two systematic reviews and one large randomized controlled trial (RCT) were the best evidence supporting the use of CIMT to improve arm function following a stroke. The first systematic review included nine randomized controlled trials that applied CIMT in acute, sub acute, or chronic stroke patients (Bonaiuti, et.al, 2007). These nine trials compared CIMT to conventional therapy programs for stroke rehabilitation. This systematic review found CIMT to be effective in improving arm function (p<.05). This suggests that CIMT is more effective than conventional therapy programs for stroke rehabilitation, in terms of upper extremity function (Bonaiuti et. al, 2007).

A second systematic review on the effectiveness of CIMT specifically looked at how well CIMT improves upper arm function (Hakkennes & Keating, 2005). This review contained 14
relevant RCTs that compared the use of CIMT to alternative forms of therapy, such as a traditional NDT therapy program, to improve upper limb function. The authors concluded that “the effect sizes across the meta-analysis calculations were all moderate to large in favor of the CIMT group” (Hakkennes & Keating, 2005, p 229).

In 2006, Wolf conducted a large randomized controlled trial involving 222 stroke survivors to test whether a two week CIMT protocol (experimental group) or traditional stroke therapy involving no treatment, pharmacological treatment, or physiological interventions (control group) resulted in greater improvements in upper extremity function. The main outcome measures consisted of the Wolf Motor Function Test (WMFT), which assesses upper extremity motor function in adults with hemiplegia. The Motor Activity Log (MAL) was used as well, which is an interviewing tool used to measure how well and how often 30 selected activities of daily living are performed (Wolf et.al, 2006).

The results of the study concluded that the CIMT group experienced more gains than the control group in the WMFT Performance Time, with a decrease in mean time from 19.3 seconds to 9.3 in the experimental group, versus 24.0 to 17.7 in the control group. In the MAL Amount of Use assessment, on a 0-5 scale, there was an increase from 1.21 to 2.13 in the experimental group versus 1.15 to 1.65 in the control group. On the MAL Quality of Movement assessment there was an increase from 1.26 to 2.23 in the experimental group versus 1.18 to 1.66 in the control group. The authors concluded that CIMT produces larger gains on all of the WMFT subtests, except the two strength tests.

CIMT reverses the phenomenon of learned non-use in the upper extremity. There is evidence supporting the use of CIMT to regain motor function in individuals who have experienced a stroke. It appears that CIMT and mCIMT are effective programs at increasing
hand function. However, there remain few studies that specifically support this. Therefore, additional research is necessary to determine the effects of CIMT/mCIMT on hand function.

Method

Research Design

This study utilized a mixed methods approach in which both quantitative and qualitative data were gathered. The quantitative data were obtained through a quasi-experimental, nonequivalent, two-group pretest-posttest design, which did not involve randomization of the subjects into study groups. A descriptive, qualitative approach was used to obtain data regarding the participants’ perceived changes in hand function and independence in performing ADLs pre-to post-intervention. Qualitative data were gathered through daily journal recordings and a focus group at the conclusion of the study. Three months following the conclusion of the study, phone calls to the participants were made to discuss the stability of the participants’ gains. However, this process was unsuccessful at gathering follow up data on all participants.

Participants

In order to participate in the study, participants had to be six months or greater post stroke, and have the ability to understand written and verbal instructions. Subjects had to demonstrate enough muscular endurance and strength to participate in all activities involved with each day’s therapy session. In addition, participants had to demonstrate the ability to complete several specific movements with their affected arm. These movements included the following: 45-90 degrees of shoulder flexion and abduction; 45 degrees of shoulder external rotation, active elbow extension; 45 degrees of supination and pronation of the forearm; a minimum of five degrees of wrist extension; and five degrees of active thumb, middle and index fingers extension.
Participants also had to be able to grasp and release a wash cloth three times in one minute (Blanton & Wolf 1999).

One further inclusionary criterion consisted of subjects attending a readiness seminar. This was included in order for participants to demonstrate their ability to walk, balance, and perform a sit-to-stand transfer with their unaffected limb immobilized in a constraint. At the seminar, participants were educated on the importance of taking off the constraint mitt when performing tasks that involved the use of both hands for safety. Subjects were also informed of all risk factors involved with the study, including physical and psychological aspects (Burns, Burridge, & Pickering, 2007).

Exclusionary criteria consisted of shoulder pain due to bursitis, rotator cuff pain, and tendonitis. Based upon the guidelines developed by Wolf, Winston, Miller, Taub, Uswatte, Morris, et al., those who scored less than a 24 on the Mini-Mental State Examination were also excluded (Phipps & Roberts, 2006). Additionally, all subjects had to receive written documentation from their physician stating that they did not have any medical conditions that would impede participation in the study, such as seizures, myocardial infarction, osteoporosis, or any other condition that would endanger the subject.

Potential participants were recruited through posted fliers at the university, where the research was conducted, as well as advertisements in the local newspaper and at area clinics. A total of eight subjects were split into four CIMT and four mCIMT groups.

Instrumentation

The Wolf Motor Function test (WMFT) was used to assess participants’ upper extremity function. The inter-tester/inter-rater reliability, and internal consistency/stability for this test is high (Wolf, Lecraw, Barton, & Jann, 1989). Seven subtests from the WMFT were used as
outcome measures to assess hand function for this study. VB (10) Lift pencil; VB (10) Lift paper clip; VD (12) Stack checker; VE (13) Flip cards; VF (14) Grip Strength; VG (15) Turning key in lock; VH (16) Fold towel (Wolf et al., 2006).

Qualitative data were obtained through notes in daily journals following each treatment session. Data were also gathered through informal interviews throughout the therapy process and documented in daily SOAP notes. Further descriptive data were gained through a post-treatment focus group.

Procedures

Study site. Therapy was conducted on the campus of a mid-sized public state university in the Midwestern U.S. Therapy took place in the occupational therapy lab as well as outdoors on the lawn of the campus. Data collection and analysis took place on the same university campus.

Data collection. Data for the quantitative portion of the study was collected the day prior to the first treatment session, and on the last day of treatment. Each subject was administered the same battery of seven subtests from the Wolf Motor Test.

For each of the subtests, a template was taped in the center of a desk placed in front of the participants. To ensure standard placement of all objects, each participant used the same template for all testing. The template consisted of an outline for each object used in each of the subtests, to ensure equal distance from each participant during testing.

The participants were seated in a chair facing and centered at the table with the task object template in front of them. For all tests, the chair was placed with the front edge of the back legs approximately 60 centimeters from the front edge of the table. Each subtest task was timed in seconds. Timing stopped if the task was unable to be performed within 120 seconds.
Furthermore, if a task was unable to be completed, the participants were automatically given a score of 120 seconds.

During administration of the test, the participants were given verbal instructions per the WMFT manual as it related to each specific task and cued to begin by saying, “ready, set, go.” Participants were instructed to perform each subtest as quickly as possible. The administrator timed each subtest with a stop watch. A pencil was placed on the object template. The timing procedure for the VB (10) lift pencil was the time elapsed from starting the subtest after the verbal cue was given to the moment the entire pencil was raised at least a half inch off the table. This same placement and timing procedure was used with the VB (10) paper clip task. For the VD (12) stack checker test, the participants were asked to stack three checkers that were placed in a row of three on the template in front of them. Timing began with the word “go” and ended the moment the checkers were stacked. During the VE (13) flip cards task, the participants had to use pincer grasp to bring three index cards to the edge of the table and flip them. The stopwatch time began with the word “go” and ended when the participant successfully flipped the third card.

To administer the VF (14) grip strength test, a dynamometer was used. The participants performed three consecutive tests, with a minute rest in between each. The average of these three tests was recorded in kilograms. While assessing VG (15) turning key in lock, the participants used the lateral pincer grasp to turn a key placed in a lock, to the side being tested, to the opposite side, and then back to the starting position. Timing began with the word “go” and ceased when the key was turned back to the original starting position.

Finally, for VH (16) fold towel task, the participants were instructed to pick up the towel ends with both hands, grasping the far corners and folding the towel lengthwise. Using only the
arm being tested, the towel was folded in half again widthwise. Timing began with the word “go” and stopped when the towel was completely folded on the table.

For qualitative data collection, the subjects also had to keep a journal that involved description of the activities they did with the mitt on and off. Also, included in the journal were home exercise programs designed by the therapist. The participants were required to follow his/her home exercise programs and make notes relative to improvements and completion.

Daily journals of the therapy sessions were also kept to supplement qualitative data collection. At the end of the two week session, a focus group was conducted with all participants, and at the end of the four week session, a focus group was conducted with only the mCIMT participants. The participants were asked the following questions: (1) What was your pre-stroke lifestyle like? How has it changed since your CVA?; (2) How has participation in the overall CIMT/mCIMT program affected your performance of daily activities?; (3) How do you perceive yourself now, compared to before your participation in the CIMT/mCIMT program?; (4) Are you satisfied with the results of the intervention?; (5) How has the intervention affected your social network?; (6) What aspects of your life have been most affected by your participation in the CIMT/mCIMT program?; (7) Did you enjoy the treatment activities used in the CIMT/mCIMT program?; (8) How has this program improved your ability to participate in social activities? Each participant was given the opportunity to respond to each of these questions openly in front of the other subjects. The student researchers recorded each of the responses to these questions using a digital recorder. This recorded information was used later by the student researchers for qualitative analysis.

**Intervention.** Prior to initiation of treatment, all subjects were educated on donning and doffing the CIMT constraint mitt, and were instructed to wear it during their therapy sessions,
extra time at home, and during weekends. A client contract and daily schedules were incorporated to improve the likelihood that protocols would be followed. A behavioral contract was administered to help subjects remember when and when not to wear the constraint mitt, and to help with accountability. The mitt had to be worn for 90% of their waking hours in the two-week CIMT group, and the top five, upper-extremity use hours per day for the mCIMT. For safety issues, the constraint had to be removed during transfers or activities that involved both hands, such as driving.

Preparatory Phase: Preparatory activities were used in preparation for participation in occupation-based and purposeful activities (AOTA, 2002). From the seated position, each treatment session began with a preparatory phase that involved bilateral upper extremity stretching and range of motion exercises. This warm up phase typically involved the participant sitting in a chair. The student therapist then performed passive range of motion (PROM) which consisted of 8-10 repetitions of scapular protraction/ retraction, flexion/extension, internal/external rotation, and circumduction of the participant’s shoulder. Next, the participant performed these movements as active range of motion (AROM). Then they performed 8-10 repetitions of shoulder shrugs.

Following ROM exercises, participant were instructed to weight bear into a large exercise ball for 20-30 seconds while sitting and then roll the ball back and forth/side to side to facilitate co-contraction. Finally, the student therapists performed sit and reach exercises while sitting in front of the participant to facilitate co-contraction of the trunk muscles.

Next, from the supine position, the participants were placed on a plinth to work on exercises in a gravity eliminated plane. While in this position, the participants did 8-10 repetitions each of scapular elevation, active scapular protraction/retraction, arm circles with
shoulders flexed at 90 degrees, assisted shoulder abduction, flexion and rotation. If needed, participants were given a ball to hold with both hands to provide for self ROM to the involved extremity. Participants with issues of increased tone wore an air splint to increase stability, and decrease high muscle tone.

As a final portion of the warm up phase, the participants returned to the sitting position where they performed pronation/supination of the wrist. They then performed 5-10 repetitions of wrist flexion/extension as well as digital flexion/extension. They also performed 8-10 repetitions each of active shoulder flexion/extension, shoulder abduction, horizontal abduction and adduction, elbow flexion/extension and arm circles.

Clients that experienced pain or soreness were administered appropriate modalities under professional supervision of the involved supervisors. These included the use of ice, heat, ultrasound, paraffin wax, and/or neuromuscular electrical stimulation (NMES). These were administered prior to the therapy sessions to alleviate any pain the client was experiencing.

*Purposeful Activities:* Selected activities that allow the client to practice and develop the skills needed to increase occupational performance (AOTA, 2002).

There were a number of purposeful activities used during treatment sessions. Activities were selected based on each individual’s skill level. After assessing the participants, selected purposeful activities were used for each client. These activities were used to provide each client with the opportunity to practice and develop the necessary skills for occupational engagement with their involved limb. Each participant had differing skill levels and required client-centered intervention when selecting purposeful activities. While the participants were wearing his/her constraint mitt, purposeful activities were performed such as stacking cones, range of motion
arch, jux-a-cisor, peg boards of varying difficulty, PNF patterns, Velcro board, finger ladder, clothes pins, thera-putty, arm ski, grip exerciser, and pinch exercises.

**Occupation-Based Activities:** Client-centered occupations matched specifically to clients’ goals (AOTA, 2002).

Treatment sessions also utilized occupation based activities that were selected based on each of the clients’ individual goals. Some of these activities included: eating, vacuuming, washing tables and windows, cooking, making a sandwich, playing cards and board games, lawn games, potting flowers, stacking dishes, sorting silverware, and taking items out of the oven and cupboards. The student therapists also used group activities such as corn hole, bocce ball, and playing cards as an instrument to encourage socialization among participants. This also allowed for each of the subjects to lend support and encouragement to one another. Lunch time offered the participants the opportunity to practice eating skills with their affected limb with the aid of a student therapist.

All activities used in the intervention process were designed to reverse learned non-use of the affected arm. The therapists based these preparatory, purposeful, and occupation based activities off the Occupational Therapy Practice Framework: Domain & Process (AOTA, 2002). The activities used followed the guidelines of CIMT and mCIMT that include shaping, chaining, and massed practice. This was done by selecting activities tailored to each client and then providing positive verbal reinforcement for improvements in task performance. The researchers also provided assistance to clients when movements could not be performed independently to help the client “shape” the use of their involved limb. As the clients’ abilities progressed, their skills could be “chained” to produce improvements in occupational performance. This was done by “massed practice” of the skills needed to achieve the improvements.
Data Analysis. Quantitative data were reported using descriptive statistics, because there were not enough participants to formulate inferential statistics. The average pre-intervention and post-intervention times for each WMFT subtest of the CIMT and mCIMT groups were used.

Qualitative data were obtained from the focus group, journal entries, daily conversations, and organized into themes. Participants’ answers to each of the questions from the focus group were written down. The researchers then analyzed these responses and wrote down common answers given by the participants for each question. The common answers were then analyzed for the development of themes used to report the qualitative findings.

Trustworthiness was addressed through the method of participant checking. According to Kreftig, this involves asking the subjects if the themes established are actual representations of their experience. The subjects are the ones who make the final decisions about whether the data is true (1990). Therefore, the method of participant checking is useful to increase trustworthiness of qualitative research findings, by discussing the themes with each participant to determine if the same conclusions could be drawn by both the researchers and subjects (1990).

To improve the trustworthiness of the qualitative findings, the authors attempted to perform a three month follow up over the phone, to discuss with the participants the themes that they developed. However, this was unsuccessful because of an inability to contact a majority of the participants. To further increase the trustworthiness, the authors used peer examination. This consisted of discussion of what themes and ideas were gathered during transcription of the tape recorded focus group and to see if the information was congruent with each other.

Results

Quantitative Findings
A total of four subjects received the traditional CIMT program and four received the mCIMT program. The quantitative data from these two experimental groups were analyzed using descriptive statistics. The averages of the pre- to post-intervention scores on the seven WMFT tests for the CIMT/mCIMT groups were calculated. Microsoft Excel software was used to calculate these averages.

_Lift Pencil Subtest._ In the mCIMT, the four subjects were tested pre-treatment on the Lift Pencil subtest and again at four weeks following the initial assessment. The scores demonstrated a 64% positive percent change in the CIMT group; four subjects were also tested pre-treatment and post-treatment. This group’s score demonstrated a -393% change.

Table 1

<table>
<thead>
<tr>
<th>VB(10) Lift Pencil</th>
<th>2 Weeks Pre</th>
<th>2 Weeks Post</th>
<th>4 Weeks Pre</th>
<th>4 Weeks Post</th>
</tr>
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<tbody>
<tr>
<td>Average Per Subject in Seconds</td>
<td>6.53</td>
<td>32.25</td>
<td>7.01</td>
<td>2.49</td>
</tr>
<tr>
<td># of Subjects</td>
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<td>4</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

_Lift Paperclip Subtest._ In the initial assessment for the Lift Paperclip subtest the mCIMT demonstrated a 67% positive change. In the CIMT group, the difference between their pre-to post-treatment scores demonstrated an 88% positive change.

Table 2

<table>
<thead>
<tr>
<th>VC(11) Lift Paper Clip</th>
<th>2 Weeks Pre</th>
<th>2 Weeks Post</th>
<th>4 Weeks Pre</th>
<th>4 Weeks Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Per Subject in Seconds</td>
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<td>3.96</td>
<td>8.44</td>
<td>2.81</td>
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<tr>
<td># of Subjects</td>
<td>4</td>
<td>4</td>
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<td>4</td>
</tr>
</tbody>
</table>
Stack Checkers Subtest. The mCIMT scores for the stack checkers subtest resulted in a 17% change from pre- to post-treatment. The CIMT group’s scores resulted in a 4% change from pre- to post-treatment.

| Table 3 |
|-----------------|-----------------|-----------------|-----------------|-----------------|
| **VD(12) Stack Checkers** | 2 Weeks Pre | 2 Weeks Post | 4 Weeks Pre | 4 Weeks Post |
| Average Per Subject in Seconds | 35.33 | 33.91 | 9.8 | 8.14 |
| # of Subjects | 4 | 4 | 4 | 4 |

Flip Cards Subtest. The mCIMT showed a 59% change in pre- to post-treatment scores. The CIMT group demonstrated a -38% change in scores.

| Table 4 |
|-----------------|-----------------|-----------------|-----------------|-----------------|
| **VE(13) Flip Cards** | 2 Weeks Pre | 2 Weeks Post | 4 Weeks Pre | 4 Weeks Post |
| Average Per Subject in Seconds | 47.58 | 65.43 | 29.64 | 12.21 |
| # of Subjects | 4 | 4 | 4 | 4 |

Grip Strength Subtest. Within the mCIMT, there was a 36% increase in grip strength among the four participants. The four participants in the CIMT group experienced a .6% change in grip strength.
Table 5

VF(14) Grip Strength

<table>
<thead>
<tr>
<th></th>
<th>2 Weeks Pre</th>
<th>2 Weeks Post</th>
<th>4 Weeks Pre</th>
<th>4 Weeks Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Per Subject</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>in kilograms</td>
<td>24.58</td>
<td>24.73</td>
<td>16.2</td>
<td>25.54</td>
</tr>
<tr>
<td># of Subjects</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

*Turn Key In Lock Subtest.* In the initial assessment of the Turn Key in Lock subtest, the mCIMT showed a -91.1% change in scores from pre- to post-treatment. The CIMT group experienced an 8% change in pre- to post-treatment.

Table 6

VG(15) Turning Key In Lock

<table>
<thead>
<tr>
<th></th>
<th>2 Weeks Pre</th>
<th>2 Weeks Post</th>
<th>4 Weeks Pre</th>
<th>4 Weeks Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Per Subject</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>in Seconds</td>
<td>36.82</td>
<td>33.85</td>
<td>3.12</td>
<td>5.95</td>
</tr>
<tr>
<td># of Subjects</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

*Fold Towel Subtest.* In the towel subtest, the mCIMT showed a 44% change in scores from pre- to post-treatment. The CIMT group demonstrated a 32% change in scores pre- to post-treatment.
Table 7

<table>
<thead>
<tr>
<th>VH(16) Fold Towel</th>
<th>2 Weeks Pre</th>
<th>2 Weeks Post</th>
<th>4 Weeks Pre</th>
<th>4 Weeks Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Per Subject in Seconds</td>
<td>20.73</td>
<td>14.13</td>
<td>12.7</td>
<td>7.11</td>
</tr>
<tr>
<td># of Subjects</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

Qualitative Findings

After analyzing the qualitative data, seven general themes were identified. Theme identification was done through a process of open coding, in which the researchers formed initial categories of the information gathered from the voice recordings, and through selective coding, where this information was formed into themes. These themes were a combination of thoughts and feelings described by both the two week and four week CIMT and mCIMT participants. The generated by the researchers after data review, transcription, and participant checking process included; (1) a dramatic decrease of participation in areas of work and leisure; (2) an increase in use of the affected hand; (3) a more positive perception of themselves; (4) expectations being met during therapy; (5) an increase in social networking; (6) feelings of having a routine again; and (7) therapy can be “fun.” In the following paragraphs, these themes are discussed using the participants own words (in vivo terms), information from personal daily journals, and transcription of the focus groups from tape recorded interviews.

Decrease in Work and Leisure

Although their lives changed, most of the participants said that their life styles didn’t change all that much following their stroke. As a general consensus, all the participants described issues they were having with independence in self care tasks, but the focus of the first focus group question was how their strokes impacted their ability to work and engage in desired leisure
activities. The participants reported difficulties in leisure activities such as golf, bowing, and fishing.

*Increase Use of Affected Hand*

Within the focus groups, participants shared that involvement in the study increased use of their affected arm and hand and that they were using it better in tasks around the house. While wearing the constraint at home they noticed they were “breaking habits” of using their non-affected arm to complete tasks, and using the affected arm and hand instead. One gentleman said not only was he happy that he was using his arm more, but “other people were noticing changes” in his performance as well. Another participant mentioned that even though it would have been faster to take the constraint off and eat with her good hand, she used her affected arm to feed herself. Furthermore, one participant reported using a vacuuming around the house and playing catch with her kids more.

*Positive Perception of Self*

The participants were asked about how their perception of themselves had changed while being involved in the program. The participants noted that they were beginning to feel better about themselves as a result of noticing improvements in use of their arm. They shared that participating in a program such as CIMT has made them aware that they need to be patient with their condition, remain positive, and work hard to get better. One participant stated, “There is no reason I can’t do what I want to do.” Another participant said “I want to see how far I can go” when discussing her improvements.

*Expectations of Therapy*

When asked to reflect upon the results experienced with the study, the participants were happy with what gains they had made during their involvement in the program. Although most of
them didn’t know what to expect out of the program, they were happy they participated. One participant said, “I feel like I am 75% better and that is good.” Many of the participants explained that if such a program was offered again they would gladly participate. One participant mentioned that her ability to perform household tasks had improved due to the increase use of her affected hand.

*Increase in Social Network*

Although each individual’s social network didn’t change outside of therapy, relationships with participants in the program were developed. While conducting the focus groups and daily treatment sessions, the participants opened up to one another and it developed into a support group for them. While participating in this program, the subjects gained friendships. They shared with each other ways that they have found that make it easier to complete everyday tasks. They encouraged each other each day to get better. One participate stated, “I am not as shy as I used to be” through her involvement in the program.

*Feeling of a Routine*

The participants were asked about aspects of their lives that were affected by participating in the CIMT or mCIMT program. There was a general consensus that during the time they were involved in the program, they had a routine again and structure to their life. They began to get used to waking up earlier and getting ready for therapy and planned the rest of their days around therapy. They also liked having home exercise programs to incorporate into their day when they weren’t in therapy; several participants reported that they became used to writing in a daily journal. One participant said, “It’s like having a job again.”
Therapy can be “Fun”

The participants were asked to reflect upon whether or not they enjoyed the overall treatment activities during the treatment sessions. All participants had something positive to say about the treatment they received. Many of them did not know that playing games such as Connect Four or Cornhole could be therapeutic. One participant stated, “I didn’t know playing cards was a part of therapy, I liked it.” The overall consensus on treatment was that it was interesting and the therapists made it fun for them. The activities made them want to come back the next day.

Discussion

This study explored the effects of a traditional and modified constraint induced movement therapy program on hand function. Participants were assessed pre- and post-intervention with subtests 10-16 of the Wolf Motor Function Test. The CIMT group displayed a decrease in the average time required to perform 4 of the 6 selected time-based subtests of the Wolf Motor Function Test. The participants in the CIMT program also displayed slight improvements in average grip strength. The mCIMT experimental group lowered their average time to complete 5 of the 6 selected time-based subtests of the Wolf Motor Function Test, and also displayed an average grip strength increase of nearly 10 kilograms. Again, if participants could not perform one of the subtests, they were disqualified and given a score of 120 seconds. With the small sample size, this greatly skewed the percent change calculated for some of the subsets.

As stated earlier, there were seven main themes identified during the qualitative portion of research. The themes were derived from the participants’ expressed thoughts, recordings in daily journal entries, and transcriptions from the tape recorded semi-structured focus groups. The
participants noticed the following; (1) a dramatic decrease in areas of work and leisure following their stroke (2) an increased use of the affected hand following the study; (3) a more positive perception of themselves; (4) expectations being met during therapy; (5) an increase in social network through participation; (6) feelings of having a routine again and; (7) therapy can be “fun.” One major theme identified by the participants was an increased use of the affected hand, along with better quality movement of the extremity. The participants noted they were automatically using their affected extremity during regular daily activities, and performing quality movements during these tasks. One participant stated that individuals he had not seen in a while commented on the changes in his performance of daily activities. The participants noted they were making progress, and many stated that if the program is offered in the future they will be back to see how much they can gain.

The results of the present study expanded on those of previous studies conducted on the use of CIMT and mCIMT. A number of previous studies mentioned in the literature review (for example, see Wolf et al., Page & Levine, and Bonifer, Anderson, & Arciniegas) found the program a useful tool in improving upper extremity function. However, to the authors’ knowledge, there is a limited amount of evidence supporting CIMT and mCIMT as a useful tool in improving hand function. The study conducted by the authors took the research further than other studies involving CIMT and mCIMT. Instead of looking at upper extremity function in general, this study analyzed hand function as the final outcome to CIMT/mCIMT.

Only one published study was found by the present authors’ that utilized the same assessment tool, WMFT, which was used in this study (Wolf et al., 2006). Furthermore, that study only analyzed the WMFT test scores pertaining to improvement of upper extremity function in general. The researchers in that study found a large improvement in upper extremity
function on the WMFT. However, those researchers did not analyze the same seven subtests for hand function as an outcome as was done in this study.

Implications

The quantitative results of this study demonstrated that participants in the CIMT group displayed a decrease in the average time required to perform 4 of the 6 selected time-based subtests of the Wolf Motor Function Test. Additionally, there was a slight improvement in average grip strength. The mCIMT experimental group lowered the average time required complete 5 of the 6 selected time-based subtests of the Wolf Motor Function Test, and also displayed an average grip strength increase of nearly 10 kilograms.

Participants all agreed that experiencing a stroke changed their life style in the areas of work and leisure. The qualitative results also showed that participation in CIMT increased use of the affected hand in daily activities, as well as the quality of movement. Their social network improved as well, with many of them developing friendships with others in the group. Furthermore, the participants all felt that the program gave them the tools necessary to continue to make gains at home.

Although the data showed a trend towards improvement of hand function, the researchers could not test for significance due to the small sample size. Only eight subjects were involved in this study. Based on the results of both the quantitative and qualitative portion of the data, it appears that CIMT/mCIMT may be an effective treatment for improving hand function following a stroke. However, the small sample size, coupled with the limitations noted previously, prevents the researchers from reporting conclusive outcomes.
Limitations of Research

In the present study, descriptive statistics was used on seven subtests of the WMFT to assess for improvement of hand function. This study found that the differences between pre and post intervention scores in both the CIMT and mCIMT program showed slight improvements. Additional studies are needed to further explore these outcomes, as the improvements were minimal and the results could not be tested for significance due to the small sample size.

Among the eight subjects used in the data analysis, several participants disqualified on some of the seven WMFT tests. This impacted the results of the data analysis. Coupled with a small sample size, these disqualifications skewed the results of the analysis. Furthermore, issues with compliance with home constraint requirements were noted with some of the participants. This could have affected the improvements made post-intervention.

While obtaining the qualitative data, the researchers used an audio recording tape from the focus group session. The participants did not always answer the questions that were asked, instead straying off topic and sharing stories. Furthermore, while the clients were asked to write in their journals daily, many of the clients were inconsistent with this requirement.

Another limitation involved concerns regarding inter-rater reliability when administering the seven sub-tests to each participant. Despite procedures instituted to promote the consistency in test administration, the manner in which the WMFT was administered was not always consistent amongst the researchers. For example, the template used for testing was taped to different tables of varying heights and the chair used to seat the participant during testing was not always measured to be in the exact position every time. This means that the data collected would have been skewed because of the lack of consistency with test administration.
Additionally, all participants were Caucasian, and of middle socioeconomic status. While the participants were screened for underlying conditions that may have impacted participation, clients who had back pain and expressive aphasia were accepted in the program. Clients with back pain were unable to perform all expected activities such as those requiring standing for long periods of time. Several participants were unable to attend all of the therapy sessions; while they were given the chance to make up the treatment time, some chose not to. One participant revealed a tendon injury two days before the end of treatment that was on his affected hand, severely limiting his fine motor capabilities. Several participants were not compliant while wearing their constraint during therapy and at home. This inconsistency in wearing their constraint may have impacted the outcomes of the study. Part of the program required that participants kept a daily journal to log when they wore the constraint and when they took it off. The purpose of this journal was to reveal any noticeable improvements with their arm. Many of the participants failed to keep up with daily entries which could have left many small improvements undetected.

*Future Research Directions*

The researchers recommend further studies be conducted focusing on hand function as an outcome to CIMT/mCIMT. In particular, randomized controlled trials with larger sample sizes should be performed that measure hand function as an outcome with CIMT.

*Conclusion*

The researchers in this study explored the effects of a CIMT and mCIMT program specifically on hand function. Quantitative data relative to the efficacy of the CIMT/mCIMT programs were gathered with subtests 10-16 of the Wolf Motor Function Test. The CIMT participants displayed a decreased average time for performance of four of the six selected time-
based subtests of the Wolf Motor Function Test. A slight increase in the average grip strength was also noted in the participants. The mCIMT participants displayed lower average times required to perform five of the six selected time-based subtests of the Wolf Motor Function Test. Additionally, the mCIMT participants displayed an average grip strength increase of nearly ten kilograms.

The qualitative data yielded seven major themes and were gathered from the participants’ expressed thoughts, daily journal entries, and transcriptions from the semi-structured focus groups. The themes included the participants’ acknowledgement of the following: (1) a dramatic decrease in areas of work and leisure (2) an increased use of the affected hand (3) a more positive perception of themselves (4) expectations being met during therapy (5) an increase in social network (6) feelings of having a routine again and (7) therapy can be “fun.” The participants expressed an increase in the amount they used their affected extremity for daily activities, along with an enhanced quality of movement in that extremity. They expressed a higher level of function, a strong desire to continue improvement, enjoyment in the therapy process, an increased perception of themselves, and a strong social connection with fellow participants.

The researchers concluded that both CIMT and mCIMT may be effective forms of treatment to improve hand function in individuals who have suffered a stroke. The subjects did express they were using their affected extremity more spontaneously, and had noticed an increase in the quality of movement. Future research should examine the effects of CIMT on hand function in further detail. Range of motion of all digits and electromyographic studies of the muscles in the hand after CIMT may be good measurements of outcomes following this program.
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