Professional Assignment Project
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A systematic review

How effective is Constraint-Induced Movement Therapy in relation to traditional therapy for patients aged 45 to 85 years, who suffered a stroke at least six months ago?
This is to certify that:

(i) the thesis comprises only our original work towards the Bachelor’s Degree

(ii) due acknowledgement has been made in the text to all other material used

Birchmeier, J., Heschel, I. & Rauscher, C.
21 January, 2009
Abstract

Aim: The aim of this systematic review was to elaborate the effectiveness of Constraint-Induced Movement Therapy for patients aged between 45 to 85 years who suffered a stroke at least six months ago in comparison to traditional therapy.

Methods: A literature search was conducted in databases such as Cinahl, Cochrane Library, Google Scholar, PEDro, PiCarta, Pub Med and Science Direct. Six of the 224 revealed articles were judged with the PEDro scale and further analyzed.

Results: The findings among the various articles are contradictory concerning the effectiveness of Constraint-Induced Movement Therapy compared to traditional treatment.

Conclusion: It can be concluded that Constraint-Induced Moment Therapy, although promising, is not more effective than traditional therapy for patients within the chronic phase of stroke.

Keywords Constraint-Induce Movement Therapy, CI – Therapy, Forced Use, CVA, Stroke and Hemiplegia
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<td>Amout of Use</td>
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<td>ARAT</td>
<td>Action Research Arm Test</td>
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<td>ARA</td>
<td>Action Research Arm</td>
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<td>CIMT</td>
<td>Constraint-Induced Movement Therapy</td>
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<td>CVA</td>
<td>Cerebral Vascular Accident</td>
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<td>Fugl-Meyer Assessment</td>
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<td>Modified Constraint-Induced Movement Therapy</td>
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<td>Neurodevelopmental Therapy</td>
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<td>PEDro Scale</td>
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<td>Traditional Rehabilitation</td>
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1 Introduction

This section will give an overview about our motivation to perform this study. The aim of this project will be explained and the hypothesis will be stated.

1.2 Motivation

The idea to write this systematic review developed during our practical neurology classes in our second year. In this period we saw our first neurological patients, which included stroke patients. We were especially interested in stroke due to its sudden onset and huge impact not only on the patient’s life but also on all family members and friends. Within that phase we started searching for the best treatment possibilities for hemiparesis of the upper extremity as a consequence of stroke. During this search we first came across the topic of Constraint-Induced Movement Therapy and started to look deeper into the topic. While gathering more information we found out that no systematic review which evaluates the effectiveness of Constraint-Induced Movement Therapy in only the chronic phase of stroke in comparison to alternative interventions had been performed. Therefore we decided to fill this gap.

1.3 Aim of this Project

Most Systematic Reviews done within the field of Constraint-Induced Movement Therapy did not specify the phase of the stroke (Bonaiuti et al. 2007; Tuke 2008; Hakkennees & Keating, 2005). In the study of Legg et al. (2004) the effects of therapy based rehabilitation services for patients one year post-stroke was discussed. Constraint-Induced Movement Therapy was only one form of these rehabilitation services. Therefore this review is the first, which evaluates the effectiveness of Constraint-Induced Movement Therapy on adult patients in the chronic phase of stroke in comparison to alternative interventions. The aim of this systematic review is to elaborate the effectiveness of Constraint-Induced Movement Therapy in comparison to traditional therapy based on the up-to-date literature.

1.4 Hypothesis

We hypothesize that Constraint-Induced Movement Therapy is more effective than traditional therapy for patients aged 45 to 85 years, who suffered a stroke at least six months ago.
2 Stroke Rehabilitation

In this section an overview of the most common treatment possibilities for stroke as well as an introduction in Constraint-Induced Movement Therapy will be given. Additionally an insight into stroke will be included. Different outcome measures frequently used within patients with a hemiparetic limb will be explained in detail.

2.1 Stroke Background

Stroke also known as cerebrovascular accident (CVA), is defined as ‘rapidly developing clinical signs of focal disturbance of cerebral function, lasting more than 24 hours or leading to death with no apparent cause other than that of vascular origin’ (WHO, 1989).

CVA’s can be divided into Ischemic and Haemorrhagic stroke. Ischemic strokes make up approximately 80% of all strokes (van Peppen et al. 2004). These strokes are caused either by atheroma itself or by emboli, which are washed up, from the heart or diseased neck vessels (Stokes, 2004). This causes obstruction of one of the major cerebral arteries or of smaller branches in the deeper parts of the brain (Stokes, 2004). Haemorrhagic strokes are frequently more severe and destructive than other strokes (Gould, 2006). These strokes can be divided into -cerebral haemorrhagic strokes and subarachnoid haemorrhage. According to van Peppen et al. (2004) intra-cerebral haemorrhagic strokes make up 10% and subarachnoid haemorrhage 5% of all strokes.

The incidence of strokes in the western world is cited at 150-250: 100 000 individuals per year (Stokes, 2004). According to Warlow (2001) the prevalence of stroke is estimated to be 5:1000 individuals and is the third leading cause of death in the western world (Stokes, 2004). The chance of having a stroke increases with age but is not a natural concomitant of increasing age (Warlow et al. 2001). A distinction is made between different phases following stroke (van Peppen et al. 2004). Van Peppen et al. (2004) describe the different phases as follows;

- Acute phase (first week after onset of stroke) and sub-acute phase (2\textsuperscript{nd} – 4\textsuperscript{th} week after stroke)
- Post-acute (1\textsuperscript{st} – 6\textsuperscript{th} months after onset of stroke)
- Chronic (>6 months after stroke)

This systematic review will focus on the chronic phase of stroke. It is though that movement ability reached a plateau in that phase (Ster & Sanders, 2007).

The signs and symptoms of stroke depend on the location of the obstruction, the size of artery involved and the functional area affected (Gould, 2006). Paresis of muscles of the arm, leg, trunk and face on one side of the body are the most common physical consequence of stroke (Fredericks & Saladin, 1996). Recovery of the function of the upper extremity is often slower than that of the lower extremity (Kwakkel et al. 1996). Over half of the patients with upper limb paresis resulting from stroke will suffer from long-term impaired arm function and an enduring disability in daily life (Kwakkel et al. 2003). Actual use of the affected arm often seems to be much less than potential use (Suputtittada et al. 2004). After suffering a stroke movements with the paretic arm cost more effort and are less efficient and accurate when compared to the non-paretic arm and therefore the patient starts to use the affected arm less and less in his daily life (van Peppen et al. 2004). Even if the patient’s condition would allow movements, the use of the affected arm is reduced.
2.2 Constraint-Induced Movement Therapy

Constraint-Induced Movement Therapy (CIMT) or ‘forced use’ is one of the treatment possibilities for patients who suffer from hemiplegia following a stroke. It is defined as a treatment method in which the use of the paretic arm is stimulated by temporary immobilization of the non-paretic arm or functional restriction with a splint, glove or sling (van Peppen et al. 2004). By such restriction Constraint-Induced Movement Therapy attempts to overcome the learned nonuse (Taub et al. 1993). The learned nonuse is a phenomenon in which the patient effectively forgets to use the affected arm due to the extreme difficulty of movement experienced immediately after the onset of stroke (Supputtitada et al. 2004).

Constraint-Induced Movement Therapy originates from seminal studies performed by Taub on monkeys which had undergone surgical somatosensory deafferentation of one arm (Tuke, 2008). In these studies Taub demonstrated that the monkeys when forced to use the affected upper extremity through immobilization of the unaffected limb could soon learn to use the affected limb even in bimanual tasks (Wolf, 2007). Taub proposes that the monkeys had undergone learned non-use and that these effects could be reversed through appropriate behavioural training (Wolf, 2007).

While the unaffected arm is immobilized, an intensive training of the paretic arm through active participation in functional activities is performed (Gillen & Burkhardt, 2004). Within these training sessions repetitive and adaptive task practice will take place, which is called shaping (Wolf, 2007). Repetitive task practice refers to continuous efforts to execute movements that normally are repeated during daily life like eating or brushing teeth (Wolf, 2007). The movements of the tasks can be varied by making it easier or more challenging (Wolf, 2007). Adaptive task practice on the other hand is a form of operant or instrumental conditioning, which is characterized by repetitions of a defined movement in a series of trials (Wolf, 2007). Each of these trials has a defined duration and the participant usually is asked to either reduce the time needed to complete the task successfully or to increase the number of successful repetitions (Wolf, 2007). During these trials the participant is encouraged by the therapist (Wolf, 2007). In order to motivate the participant to perform better during the next trial, the therapist shows the performance record to the patient (Wolf, 2007).

Within the original Constraint-Induced Movement Therapy concept, the less affected arm is restricted during 90% of the waking hours for a period of two weeks (Page et al. 2008). Besides that the patients participate in six-hour activity
sessions using their more affected limb on 10 of the 14 intervention days (Page et al. 2008). That intervention protocol is very intensive and therefore many facilities cannot administer it (Page et al. 2008). Moreover, patients who participated in Constraint-Induced Movement Therapy interventions reported that they grew tired of wearing the restraint and they had difficulty with full adherence since cheating with the uninvolved hand was a frequent temptation (Blanton & Wolf, 1999).

To make the intervention more practical a modified form of Constraint-Induced Movement Therapy (mCIMT) was developed by Page and colleagues which combines structured half-hour functional practice occurring 3 days per week with restriction of the less affected arm 5 days per week for 5 hours during a period of 10 weeks (Wolf, 2007 & Page et al. 2008).

The original and the modified form of Constraint-Induced Movement Therapy are used and will be considered in this systematic review.

2.3 Traditional Therapy

When talking about traditional therapy Cuccurullo et al. (2004) mention exercise programs that consist of range of motion exercises, strengthening, mobilization, compensatory techniques, and endurance training. Within these exercise programs special focus is put on the repetition of basic movements and postures in order to memorize and develop them.

2.3.1 Bobath

Bobath approach, also known under the term Neurodevelopmental Therapy (NDT) was designed by Bobath in 1978 (Cuccurullo et al. 2004). Reflex inhibitory patterns are used to reduce tone and abnormal postures and these patterns stimulate advanced postural reactions to enhance motor recovery (Dobkin et al. 2003). Pressure or support is used on key points in order to inhibit or facilitate movements. These key points are on the proximal limb or on the trunk. Abnormal movements provide abnormal sensory feedback and therefore reinforce limited non-selective, abnormal movement (Dobkin et al. 2003).

Even though weak and unresponsive muscles could be strengthened by provoking flexor (e.g. shoulder, elbow or wrist) or extensor (e.g. knee, ankle plantar flexors) synergies, Bobath therapists avoid this provocation, since it could lead to an increase in abnormally enlarged tonic reflexes and spasticity (Dobkin et al. 2003). The goal of Bobath is to inhibit primitive patterns of movement and facilitate automatic, voluntary reactions and subsequent normal movement patterns (Cuccurullo et al. 2004).

2.3.2 Brunnstorm Approach

Brunnstorm designed the training procedure, called Brunnstorm Approach, in 1970 (Cuccurullo et al. 2004). This approach is based on the concept that the central nervous system regresses to phylogenetically older patterns of movements (Cuccurullo et al. 2004).

It facilitates synergies by using cutaneous and proprioceptive sensations and tonic neck and labyrinthine reflexes. (Dobkin et al. 2003). This approach is mostly used for patients who show persistent hypotonia and hemiplegia (Dobkin et al. 2003). The goal of this approach is to teach the patients to use and control the motor patterns by facilitating synergies (Cuccurullo et al. 2004). Dobkin et al. (2003) state that this approach is the opposite of Bobath.
2.3.3 Exercise Therapy

Exercise therapy is defined to be “motion of the body or its parts to relieve symptoms or to improve function, leading to physical fitness, but not physical education and training” (Exercise Therapy, 1998). This can be achieved for example by letting the patient train on a treadmill and/or a stationary bike.

2.3.4 Motor Learning (Relearning)

Carr and Shepard developed Motor Learning (Relearning) in 1985. It is also known under the term Carr and Shepard approach (Cuccurullo et al. 2004). This method is based on cognitive motor relearning, and the goal is to relearn the patient how to move functionally and how to solve problems during new tasks. This approach emphasizes on functional training of specific tasks. It teaches general strategies of how to move functionally and how to solve problems during attempts at new tasks (Cuccurullo et al. 2004).

2.3.5 Proprioceptive Neuromuscular Facilitation

Proprioceptive Neuromuscular Facilitation (PNF) was initiated by Knott and Voss (1968). It facilitates mass movement patterns against resistance in a spiral or diagonal motion during flexion and extension (Cuccurullo et al. 2004). Proprioceptive is the information concerning movement and position of the body that is given by sensory receptors. Neuromuscular is everything involving the nerves and muscles. Facilitation is the term used when making it easier for the patient (Adler et al. 2003).

In order to treat the patient according to the principles of PNF, each treatment has to be an overall positive approach (Adler et al. 2003). Specific techniques include repeated quick stretch, contraction, contraction-relax-action, and rhythmic stabilization (Dobkin et al. 2003). In rhythmic stabilization the patient tries to hold the arm still as resistance is applied by the therapist in an opposite direction (Dobkin et al. 2003). The primary goal of PNF is to help achieve the patients highest level of function by making use of proprioceptive sensory stimuli and brain stem reflexes to facilitate the desired movement and inhibit unwanted movements (Adler et al. 2003).

2.3.6 Rood

This method of neurological rehabilitation was invented by Noll et al. in 1996. It is also known under the term Sensorimotor Approach (Cuccurullo et al. 2004). Facilitatory or inhibitory inputs are achieved through the use of sensorymotor stimuli, including fast brushing, light touch, stroking, icing, stretching, tapping, and applying pressure and resistance to promote contraction of proximal muscles (Dobkin et al. 2003). One common example is light brushing of the lips to facilitate both flexion of the hemiplegic arm and a hand-to-mouth pattern of movement (Dobkin et al. 2003). The aim of this approach is the modification of muscle tone and voluntary motor activity using cutaneous sensorimotor stimulation (Cuccurullo et al. 2004).

2.4 Neuroplasticity

Neuroplasticity, attributed to the Polish neuroscientist Jerzy Konorski, refers to the changes that occur in the organization of the brain gained through experiences (Chudler, 2008) or in other terms is the brain’s ability to act and react in ever-changing ways (Britannica, 2009). Plasticity is said to describe the ability of modification of the brain and is found in all kinds of brain
structures (Shumway-Cook & Woollacott, 2001). It does not consist of just one simple type of physical or chemical event but consists out of many complex processes within our brain (Chudler, 2008). According to Britannica (2009) there are four major patterns of plasticity:

- *Functional map expansion* → results in changes to the amount of brain surface area dedicated to sending and receiving signals from some specific part of the body
- *Compensatory masquerade* → brain cells reorganize existing synaptic pathways
- *Homologous region adoption* → allows one entire brain area to take over functions from another distant area that has been damaged
- *Cross model reassignment* → this allows one type of sensory input to entirely replace another damaged sensory input

The ability of neuroplasticity allows the neurons in the brain to lay new pathways for neural communication and to rearrange already existing neurons throughout the whole life. Therefore it can be concluded that neuroplasticity aides in the processes of learning, memory, and adaptation through experience (Britannica, 2009). If the brain would not have this ability humans would not be able to memorize a new fact or master a new skill, form a new memory or adjust to a new environment. They would also not be able to recover from a brain injury (Britannica, 2009). Stokes (2004) states that within central injuries the neurones that have not been lost take over the role of neurons that are no longer present but whose peripheral targets are still intact.

The complex processes described by Chudler (2008) enable the brain to recover, sometimes with astonishing completeness, from head injury, brain disease, or cognitive disability (Britannica, 2009). Neuronal activity stimulates the promotion of new connections, therefore therapy should attempt on stimulating particular neurons that have not been active in order to promote self-repair and reorganization. This should be achieved through specific motor activities (Hopes, 2008). Hopes (2008) also states that Constraint-Induced Movement Therapy is a successful way for the brain to form and strengthen the connections that are necessary in order to perform a movement. The changes that occur following Constraint-Induced Movement Therapy, determined by Transcranial Magnetic Stimulation (TMS), include an expanded representation of the cortical maps that pertain to a specific muscle in the more affected hand (Mark et al. 2006). Also an altered regional cerebral blood flow distribution was found following Constraint-Induced Movement Therapy (Mark et al. 2006). Mark et al. (2006) describe, that there have been several findings which state that Constraint-Induced Movement Therapy expands the extent of the motor cortex which is associated with hand movements, this expand either facilitates the hand use or results in increased hand use during training. Overall neuroplasticity seems to be stimulated by Constraint-Induced Movement Therapy.

### 2.5 Outcome Measures

#### 2.5.1 Action Research Arm Test

The Action Research Arm Test (ARAT or ARA) (Appendix II) developed by Lyle was based on the upper extremity function test of Carroll (Ching-Lin, 1998). It is an observational test used to determine the dexterity of the upper limb function and it was designed to assess the recovery of the upper limb following cortical damage (McDonnell, 2008). In order to perform this test correctly non-standard equipment is required, such as: blocks of wood in various sizes, cricket ball, stone, jug and glass, tube, washer and bolt, ball bearing and a marble. The test consists of 19 sub-items (grasp, grip, pinch and gross arm movement) and each item is rated on a 4-point scale ranging from 0 (no movement possible) to 3 (movement performed normally) (McDonnell,
2008). The sub-items are ordered in such a way that if the patient is able to perform the most difficult item, it predicts success within all of the easier items. That means if the patient scores 3 on the most difficult item (number one), the patient scores 3 points on all the other points as well. On the other hand if the patient fails item number one and two (easiest item), it predicts failure with all items of greater difficulty (Ching-Lin, 1998). According to Ching-Lin (1998) the ARAT is extremely reliable for each of the subscales as well as the total scale when performed by different raters. Different users of the ARAT achieved consistent results (Chin-Lin, 1998). Van der Lee et al. (2001) also stated that the ARAT shows a high inter-rater and retest reliability in studies involving patients with stroke. The intra-rater reliability of the ARAT was tested by Wagenaar et al. (1990), van der Lee et al. (2001) and Yozbatiran et al. (2008) and was reported to be excellent.

2.5.2 Motor Activity Log

The Motor Activity Log (MAL) (Appendix III) is a scripted, structured interview that was developed by Taub et al. (1993) in order to measure the effects of Constraint-Induced Movement Therapy on functionality of the hemiparetic arm. It is used to assess how stroke survivors use their more-impaired arm and hand during activities of daily living (Uswatte et al. 2005). For each activity there are two scores, one for the amount of use (AOU), and one for the quality of movement (QOM) of the paretic arm. The questions concern daily life activities performed during the past week or occasionally the past year. According to van der Lee et al. (2004) possible scores range from 0 (never used the affected arm for this activity) to 5 (always uses the affected arm for this activity just as well as before the stroke). The original test consisted of 19 items, rated on a 4-point ordinal scale (0 to 3). A sum score can be reached that reaches form 0 (none of the movements can be performed) to 45 (all movements are performed normal) (van der Lee, et al. 2004). Uswatte et al. (2005) support the validity of the participant QOM scale, as well as the internal consistency, test-retest reliability, stability and responsiveness of the participant QOM. The participant AOU and caregiver QOM and AOU scales were internally consistent, stable, and sensitive, but were not reliable (Uswatte et al. 2005). According to Uswatte et al. (2005) the patient QOM scale reliably and validly assesses more impaired arm use outside the laboratory in individuals with mild to moderate hemiparesis after stroke.

2.5.3 Fugl-Meyer Assessment

The Fugl-Meyer Assessment (FMA) is a stroke-specific, performance-based impairment index (StrokEngine-Assess 2008). It was designed by Fugl-Meyer in 1975 to assess the functionality of the hemiparetic limb of post-stroke patients, such as motor functioning, balance, sensation and joint functioning. It is based on Brunnstrom and Twitchell’s ontogenetic concept of motor recovery (StrokEngine-Assess 2008).

In order to perform the test correctly the following tools are required; a mat or bed, scrap of paper, ball, cotton ball, pencil, hammer, cylinder (small can or jar), goniometer and a stopwatch (StrokeEngine-Assess 2008). The scale contains five domains (motor functioning, sensory functioning, balance, joint range of motion and joint pain), and there are 155 items in total (StrokeEngine-Assess 2008). A mean administration time of 58 minutes is mentioned by Maloin et al. (1994). The scale items are scored on the ability to complete the item, using a 3 point ordinal scale where 0 = cannot be performed, 1 = performs partially and 2 = performs fully. There is a total score possible of 226 points (StrokeEngine-Assess, 2008). Points are divided among the domains as follows:
- **Motor score:** ranges from 0 (hemiplegia) to 100 points (normal motor performance).
  Divided into 66 points for upper extremity and 34 points for the lower extremity.
- **Sensation:** ranges from 0 to 24 points.
  Divided into 8 points for light touch and 16 points for position sense.
- **Balance:** ranges from 0 to 14 points.
  Divided into 6 points for sitting and 8 points for standing.
- **Joint range of motion:** ranges from 0 to 44 points.
- **Joint pain:** ranges from 0 to 44 points.

Classifications for impairment severity have been proposed based on FMA total motor scores (out of 100 points):

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<td>&lt; 50</td>
<td>Severe</td>
<td>0 – 35</td>
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<tr>
<td>50 – 84</td>
<td>Marked</td>
<td>≤ 84</td>
</tr>
<tr>
<td>85 – 94</td>
<td>Moderate</td>
<td>85 – 95</td>
</tr>
<tr>
<td>95 – 99</td>
<td>Slight</td>
<td>96 – 99</td>
</tr>
</tbody>
</table>


Three studies (Lin et al., 2004, Platz et al. 2005 & Ducan et al. 1983) found an excellent inter-rater reliability of the total score of FMA. The test-retest reliability for the FMA was said to be excellent ([StrokeEngine-Assess, 2008](http://www.medicine.mcgill.ca/strokeengine-assess/module_fmaPsycho-en.html)).
3 Methods

This section gives an insight into the research process, and the selection of the included studies.

A computerized search was undertaken to identify randomized control trials (RCT’s), controlled trials, quasi-randomized control trials, and clinical trials. Randomized controlled trials or quasi-randomized trials were preferred since they are less susceptible to systematic bias, specifically selection bias, compared with other study designs.

The search was conducted on

- PEDro
- PiCarta
- Science Direct
- Cinahl
- PubMed
- Cochrane
- Google Scholar

The following keywords were used;
- Constraint-Induced Movement Therapy
- CI – Therapy
- Forced Use
- CVA
- Stroke
- Hemiplegia

As well as MeSH terms (Appendix I).

In order to detect high quality articles, a reliable criteria list for judging the included articles was used. According to Katrak et al. (2004) there is no golden standard in critical measurement tools for the quality of a study.

The Physiotherapy Evidence Database (PEDro) scale was used, because it is internationally known and a reliable measurement tool (Tooth et al. 2005 & Maher et al. 2003). This scale contains ten criteria, each scoring either 1 for yes or 0 for no (Maher et al. 2003). The scale assesses randomisation, allocation concealment, comparability at baseline, blinding of subjects, therapists and assessors, as well as the measurement of at least one key outcome obtained from more than 85% of the subjects initially allocated to groups, intention to treat analysis, between group comparison, and measures of variability provided for at least one key outcome measure. Geddens et al. (2005) stated that the inter-rater reliability scored excellent within the PEDro scale. The PEDro scale is a reliable measuring tool for rating the quality of RCTs (Tooth et al. 2005). The reliability of the PEDro scale is said to be “fair” to “good” (Maher et al. 2003).

In order to provide good inter-rater reliability we made use of the guideline provided for usage of the scale items. The PEDro list was developed to assess studies that are relevant in physiotherapy and has been deduced from the Delphi list.
Studies were included in the review when meeting following inclusion criteria:
(1) the intervention was Constraint-Induced Movement Therapy, in comparison to Traditional Therapy (Bobath approach, NDT, PNF, Brunnstorm approach, Motor Learning (Relearning) approach, Rood, exercise therapy)
(2) patient population aged between 45 and 85 years, at least 6 months after a left or right sided stroke
(3) the time of intervention had to be over a period of a minimum of 10 days, at least 3 hours a day
(4) only articles in English or German
(5) the outcome measures had to be functionality, strength or dexterity
(6) the article had to score at least 4 points on the PEDro scale

The three researchers judged all the selected studies independently using the PEDro scale. Disagreements were discussed in order to resolve them.

Before submitting a product to our coach, the separate parts of our final paper were sent to our external experts. The experts checked for the content as well as the English. After receiving feedback we made some changes if necessary according to our external expert’s comments and our own opinion. To improve the quality of our article, each part was proof read by all group members independently. On BSCW a folder was established in order to facilitate the process of giving feedback.
4 Results

This chapter gives a summary of the included studies as well as an overview of the different outcome findings. The judgments performed by every researcher are listed in a table, and discussed.

4.1 Original

4.1.1 Taub et al. 1993

Taub et al. (1993), was interested in the findings of improvement extent and quality of motor function in activities of daily life. The four participants in the intervention group received treatment of 6 hours every weekday during a 14-days period. The unaffected limb was placed in a splint and sling which had to be worn at all times during waking hours except during specific activities. In the comparison group the subjects had to fulfil 3 different tasks. (1) Education and propaganda to use the affected arm in daily activities, (2) physical therapy focused on passive movement, joint play, muscle tone and sensory loss, (3) home exercises. Taub et al. recorded significantly improvement in time efficiency in the Constraint-Induced Movement Therapy group (-30%) versus the control group (-2.2%) in the Motor Ability Test. Additionally quality of movement and functional ability were significantly improved among the intervention group in comparison to the control group on both the Emory Test and the Arm Motor Activity Test. They also state that there was a significant difference (p <0.01) in favour of the Constraint-Induced Movement Therapy group on the Motor Activity Log. The conclusion drawn from this study is that motor ability can be significantly increased by interventions which are effective in overcoming learned non-use.

4.1.2 Van der Lee et al. 1999

Van der Lee et al. (1999) performed a study which evaluated the outcomes on the basis of activities and dexterity. Included were people who were at least one year post stroke. The Constraint-Induced Movement Therapy group was treated for 2 weeks, 5 days a week for 6 hours a day. These 6 hours were also the minimal amount of restriction of the less affected arm. The treatment sessions were held in groups of four. The main focus in both groups aimed at functional goals, e.g. housekeeping activities, handicraft and games. The control group was treated according to the Neurodevelopmental Therapy in groups of four for the same amount of time as the Constraint-Induced Movement Therapy group. The Action Research Arm Test scores of the Constraint-Induced Movement Therapy group did not demonstrate a significant difference when compared with the control group. Also the analysis of the Fugl-Meyer Assessment Scale did not show a significant difference between the two treatment interventions. The Amount of Use Scale of the Motor Activity Log showed significantly more improvement within the Constraint-Induced Movement Therapy group when compared with the control group but no significant differences were found on the Quality of Movement Scale. Van der Lee et al. concluded that treatment focused on arm function is still possible in patients more than a year post-stroke.

4.1.3 Suputtitada et al. 2004

Suputtitada and colleagues (2004) main purpose was to evaluate the effectiveness of Constraint-Induced Movement Therapy on dexterity of the affected upper extremity in chronic stroke patients. The first group received Constraint-Induced Movement Therapy of two consecutive weeks, 5 days a week for 6 hours a day. The non-affected arm was restricted with a glove. In the
for chronic control group the subjects were treated according to Neurodevelopmental Therapy. All activities were carried out bimanually and if necessary, the unaffected arm supported the affected arm. The outcome of the Action Research Arm test (ARA) showed a significant main effect of treatment in both groups. While the results in Hand grip and Pinch strength only showed significant effects in the Constraint-Induced Movement Therapy group. Out of these findings Suputtitada et al. concluded that Constraint-Induced Movement Therapy has an advantage stroke and it could be an efficacious technique to improve upper limb function.

4.2 Modified

4.2.4 Page et al. 2004

Page et al. (2004) compared modified Constraint-Induced Movement Therapy to traditional rehabilitation, focusing on Proprioceptive Neuromuscular Facilitation (PNF) and a group with no therapy during a 10-week period. The modified Constraint-Induced Movement Therapy group had half an hour physiotherapeutic and occupational treatment, 3 days a week and 5 hours of restraint of the less affected upper limb every weekday. The exercise group received the same amount of treatment, mainly PNF and compensatory techniques. The last group did not receive any treatment. A significant difference in favour of the modified Constraint-Induced Movement Therapy was found on the Fugl-Meyer Assessment. On the Action Research Arm test (ARA) both the traditional rehabilitation and the modified Constraint-Induced Movement groups both showed a significant difference when compared to the control group but no difference was found between modified Constraint-Induced Movement Therapy and traditional therapy subjects. Also the outcome of the Motor Activity Log in both Amount of Use scale (AOU) and Quality of Movement scale (QOM) showed an increase in the modified Constraint-Induced Movement Therapy group whereas the exercise group and control group did not improve greatly. Page et al. (2004) concluded that the result of this study showed that cortical reorganization and functional improvements can be realized following practice periods of lower duration.

4.2.5 Wu et al. 2007

Wu et al. (2007) concentrated on the motor control of the upper extremity, looking at unilateral and bimanual functional tasks during daily activities. Both groups were evaluated with a kinematic analysis. The modified Constraint-Induced Movement Therapy group had an intensive training for 2 hours per day, 5 days a week, for 3 weeks. During the 3 week period the unaffected arm was placed in a mitt for 6 hours every weekday. The training primarily consisted of shaping. The same intensity was applied for the control group. Patients were engaged in Neurodevelopmental Therapy, concentrating on balance training, stretching, weight bearing and fine-motor tasks. The results show statistically significant but modest effects of modified Constraint-Induced Movement Therapy on reaching kinematics. The modified Constraint-Induced Movement Therapy group showed more pre-planned movement control after treatment than the control group did. Wu et al. (2007) also describe a significant difference on the Motor Activity Log in favour of the modified Constraint-Induced Movement Therapy group (AOU: p<0.0001, QOM: p=0.012). Similar findings were seen with the Functional Independence Measure table, the scores were significantly higher in the modified Constraint-Induced Movement Therapy group than in the control group (p = 0.004). In conclusion, modified Constraint-Induced Movement Therapy was associated with greater improvement than the control group in daily functioning as well as in motor control.
4.2.6 Page et al. 2008

This study of Page et al. (2008) focused on the changes in fine motor function within patients who suffered a stroke more than 12 months ago. The aim was to compare the efficacy of modified Constraint-Induced Movement Therapy compared to a time-matched exercise program in subjects given a minimal spontaneous recovery. The intervention consisted of half-hour, one-on-one session of more affected arm therapy occurring 3 days per week during a 10-week period. The second component of the modified Constraint-Induced Movement Therapy intervention was a restriction of the less affected arm every weekday for 5 hours. Within the same time period subjects in the exercise group received half-hour, therapy sessions on the more affected arm 3 days per week for 10 weeks. Approximately 80% of each session focused on Proprioceptive Neuromuscular Facilitation. The third group did not receive any therapy. Analyses revealed significant pretest-posttest changes in Motor Activity Log scores for the modified Constraint-Induced Movement Therapy group on both the Amount of Use scale (p<0.01) and the Quality of Movement scale (p<0.01). There was no significant difference shown in the exercise group and the control group. Page et al. (2008) mentioned a treatment effect was seen on the Action Research Arm Test (p<0.0001), showing significant differences in favour of the modified Constraint-Induced Movement Therapy group in comparison to the exercise group and the control group. In the conclusion of Page et al. (2008), it is mentioned that Constraint-Induced Movement Therapy is not reimbursed and is therefore difficult to implement in many clinical settings.

4.3 Comparison of studies

4.3.7 Interventions

Constraint-Induced Movement Therapy

Within the included studies two different concepts of Constraint-Induced Movement therapy were used. Three studies used the original Constraint-Induced Movement Therapy concept (Taub et al. 1993, van der Lee et al. 1999 & Suputtittada et al. 2004). The remaining three studies (Page et al. 2004, Wu et al. 2007 & Page et al. 2008) treated the patients with modified Constraint-Induced Movement Therapy. It has to be stated though, that Wu et al. (2007) used a different form of modified Constraint-Induced Movement Therapy, which was more time-consuming than the interventions of Page et al. (2004) and Page et al. (2008), but therefore only over a three-week period. Detailed information about the different Constraint-Induced Movement Therapy interventions used within the included studies is presented in the Table 2.
In order to meet the inclusion criteria of this systematic review, the studies had to compare Constraint-Induced Movement Therapy to a form of traditional therapy. As mentioned earlier Neurodevelopmental Therapy (NDT) and Proprioceptive Neurofacilitation (PNF) are the most common forms of traditional therapy used within stroke rehabilitation (Sterr & Sanders 2006). Van der Lee et al. (1999), Suputtitada et al. (2004) and Wu et al. (2007) compared Constraint-Induced Movement Therapy to NDT. On the other hand Page et al. (2004) as well as Page et al. (2008) made use of the PNF concept in order to come to a result of how effective Constraint-Induced Movement Therapy is in comparison to traditional therapy. These two studies also included a control group, which received no treatment during the intervention period. The remaining study of Taub et al. (1993) compared Constraint-Induced Movement Therapy to a combination of three different exercise programs (Table 5).

### Population

The included studies presented a variety of subjects’ characteristics. The duration since the onset of stroke within the included studies ranged from 1 to 20 years. Within this systematic review the population’s average age ranged from 53.9 years (Wu et al. 1993) to 60.1 years in the experimental group of Scuputtitada et al. (2004). With 69 participants (CIMT: n=33; TR: n=36) Suputtitada et al. (2004) included the largest amount of subjects. The study that showed the smallest sample size is Taub et al. (1993) with 9 subjects (CIMT: n=4; TR: n=5). More detailed information can be found in Table 5.
4.3.9 Outcome Measures

Five of the six articles (Taub et al. 1993, van der Lee et al. 1999, Page et al. 2004, Wu et al. 2007 & Page et al. 2008) used the Motor Activity Log (MAL). Wu et al. (2007) and Taub et al. (1993) stated that MAL was said to be significantly in favour of Constraint-Induced Movement Therapy. Van der Lee et al. (1999) did not mention overall findings for the MAL but stated that the Amount of Use scale showed significantly more improvement in the Constraint-Induced Movement Therapy group. The Quality of Movement scale on the other hand did not differ significantly between the treatment interventions. For the MAL there were no in between group results demonstrated within the studies of Page et al. (2004) and Page et al. (2008)

The Fugl-Meyer Assessment Scale (FMA) was used by three research teams (van der Lee et al. 1999, Page et al. 2004 & Page et al. 2008) in order to evaluate the gains in functionality. Van der Lee et al. (1999) and Page et al. (2008) found no significant difference in the outcome measures. On the contrary Page et al. (2004) stated that there was a significant difference shown.

Four studies (van der Lee et al. 1999, Suputtitada et al. 2004, Page et al. 2004 & Page et al. 2008) used the Action Research Arm Test (ARAT) to determine the dexterity of the affected arm after a stroke. A significant difference between the intervention groups was found by Page et al. (2008) and Suputtitada et al. (2004). No significant difference was found by van der Lee et al. (1999) and Page et al. (2004).

The study of Suputtitada et al. (2004) was the only one which included the hand grip and pinch strength as a measurement tool. They documented that there was a significant effect in favour of the Constraint-Induced Movement Therapy.
### Table 3 Outcome Measures

<table>
<thead>
<tr>
<th>Study</th>
<th>ARAT/ARA</th>
<th>MAL</th>
<th>FMA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pretest</td>
<td>Posttest</td>
<td>Pre</td>
</tr>
<tr>
<td>Taub et al., 1993</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CIMT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Traditional Therapy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre</td>
<td>9.25</td>
<td>14</td>
<td>9.25</td>
</tr>
<tr>
<td>van der Lee et al., 1999</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CIMT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Traditional Therapy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre</td>
<td>33.40</td>
<td>39.20</td>
<td>2.2</td>
</tr>
<tr>
<td>Post</td>
<td>(10.6)</td>
<td>(13.10)</td>
<td>(1.0)</td>
</tr>
<tr>
<td>Traditional Therapy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre</td>
<td>28.30</td>
<td>30.00</td>
<td>1.7</td>
</tr>
<tr>
<td>Post</td>
<td>(13.3)</td>
<td>(13.9)</td>
<td>(1.2)</td>
</tr>
<tr>
<td>Suputtitada et al., 2004</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CIMT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Traditional therapy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre</td>
<td>41.00</td>
<td>55.00</td>
<td>(26-51)</td>
</tr>
<tr>
<td>Post</td>
<td>(26-51)</td>
<td>30.00</td>
<td>(10-51)</td>
</tr>
<tr>
<td>Page et al., 2004</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mCIMT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Traditional Therapy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre</td>
<td>26.20</td>
<td>37.80</td>
<td>+2.38</td>
</tr>
<tr>
<td>Post</td>
<td>18.00</td>
<td>27.50</td>
<td>+0.33</td>
</tr>
<tr>
<td>Control</td>
<td>29.00</td>
<td>23.80</td>
<td>+0.11</td>
</tr>
<tr>
<td>Wu et al., 2007</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mCIMT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Traditional Therapy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre</td>
<td>0.95</td>
<td>2.32</td>
<td>1.21</td>
</tr>
<tr>
<td>Post</td>
<td>(0.89)</td>
<td>(1.45)</td>
<td>(1.24)</td>
</tr>
<tr>
<td>Control</td>
<td>1.11</td>
<td>1.45</td>
<td>1.33</td>
</tr>
<tr>
<td>(1.01)</td>
<td>(1.41)</td>
<td>(1.44)</td>
<td>(1.45)</td>
</tr>
<tr>
<td>Page et al., 2008</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mCIMT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Traditional Therapy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre</td>
<td>29.69</td>
<td>40.54</td>
<td>49.1</td>
</tr>
<tr>
<td>Post</td>
<td>(7.54)</td>
<td>(8.18)</td>
<td>(7.44)</td>
</tr>
<tr>
<td>Control</td>
<td>25.69</td>
<td>29.17</td>
<td>+0.6</td>
</tr>
<tr>
<td>(8.76)</td>
<td>(10.0)</td>
<td>(12.08)</td>
<td>(12.00)</td>
</tr>
<tr>
<td>(13.61)</td>
<td>(16.75)</td>
<td>(13.24)</td>
<td>(15.69)</td>
</tr>
</tbody>
</table>
4.3.10 PEDro Scale Outcomes

Studies that scored highest on the PEDro Scale, namely van der Lee et al. (1999) and Page et al. (2008), had a bigger influence on the interpretation of the results. The scores listed (Table 4) show that in not one of the studies included the therapists were blinded and only Page et al. (2008) worked with subjects that were blinded. The intention-to-treat was only mentioned by van der Lee et al. (1999). On the other hand it must be stated, that all the included studies showed baseline similarities of the different randomly allocated groups, measurements of at least one key outcome from 85% of the subjects, as well as between group comparisons.

*Table 4* PEDro Scale judgements

<table>
<thead>
<tr>
<th>Author</th>
<th>Random allocation</th>
<th>Concealed allocation</th>
<th>Baseline comparability</th>
<th>Blind subjects</th>
<th>Blind therapists</th>
<th>Blind assessors</th>
<th>One key outcome from 85% of subjects</th>
<th>Intention-to-treat analysis</th>
<th>Between group comparisons</th>
<th>Point estimates and variability</th>
<th>∑</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taub et al., 1993</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>N</td>
<td>5</td>
</tr>
<tr>
<td>van der Lee et al., 1999</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>8</td>
</tr>
<tr>
<td>Suputtitada et al., 2004</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>N</td>
<td>5</td>
</tr>
<tr>
<td>Page et al., 2004</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>7</td>
</tr>
<tr>
<td>Wu et al., 2007</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>6</td>
</tr>
<tr>
<td>Page et al., 2008</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>8</td>
</tr>
</tbody>
</table>
**Table 5** Summary of included Studies

<table>
<thead>
<tr>
<th>Author</th>
<th>No. of Subjects</th>
<th>Treatment</th>
<th>Control Group</th>
<th>Time post stroke</th>
<th>Duration of treatment</th>
<th>Follow up</th>
<th>Outcome Measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taub et al. 1993</td>
<td>9 (CIMT: n=4; TR: n=5)</td>
<td>Unaffected limb was secured in a resting hand split and then placed in a sling. The restraint was to be worn at all times during waking hours for 14 days. Patients had 6h/d training of ADLs</td>
<td>Focus was on the involved extremity. The patients got 4 times/day for a 10min verbal motivation and instruction to use the affected arm. Second, subjects got &quot;physical therapy&quot; focused on passive ROM, joint play, muscle tone and sensory loss. Third, patients were given self-range-of-movement exercises to carry out at home for 15min/day.</td>
<td>Range 1.2-18 years (CIMT: median 4.1 years; Control: median 4.5 years)</td>
<td>2 weeks</td>
<td>1,2,3 and 4 weeks and 2 years</td>
<td>MAL, passive ROM (each joint of the affected limb), Emory Motor Function Test, AMAT, cognitive test.</td>
</tr>
<tr>
<td>van der Lee et al. 1999</td>
<td>62 (CIMT: n=31; TR: n=31)</td>
<td>Group of 4 subjects received the same treatment for 2 consecutive weeks, 6h/5d. Healthy arm immobilized by a resting splint.</td>
<td>Treated with the NDT method 6h/5d.</td>
<td>Range 1-20 years (median 3 years)</td>
<td>2 weeks</td>
<td>3,6 weeks and 6,12 months</td>
<td>ARA (primary outcome measurement); FMA; MAL</td>
</tr>
<tr>
<td>Suputtitada et al. 2004</td>
<td>69 (CIMT: n=33; TR: n=36)</td>
<td>Patients were treated in groups of 3-4 on a 5 day basis 6 hours. The healthy hand was covered by a glove.</td>
<td>Got the same intensity as the CIMT group but with NDT method.</td>
<td>Range 1-10 years</td>
<td>2 weeks</td>
<td>3-5 days</td>
<td>Action Reach Test (ARA), Hand grip and pinch strength</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Author</th>
<th>No. of Subjects</th>
<th>Treatment</th>
<th>Control Group</th>
<th>Post stroke</th>
<th>Duration of treatment</th>
<th>Follow up</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Page et al. 2004</td>
<td>17 (mCIMT: n=7; TR: n=4; Control: n=6)</td>
<td>30 min session 3times/wk of physical therapy (PT) and occupational therapy (OT) for 10 weeks. OT-Treatment concentrated on functional tasks, strengthening and/or compensatory techniques and shaping techniques. PT-treatment largely concentrated on lower limb activities and stretching. The less affected upper limb was restrained (cotton hemsling) for 5h every weekday.</td>
<td>(2) 30 min consecutive PT and OT sessions, 3d/wk for 10 weeks. 80% focused on PNF techniques with emphasis of functional tasks and stretching. 20% focused on compensatory techniques using the less affected side.</td>
<td>Range 14-74 months (mean 32.3 months)</td>
<td>10 weeks</td>
<td>Directly</td>
<td>FMA; ARA; MAL</td>
</tr>
<tr>
<td>Wu et al. 2007</td>
<td>30 (mCIMT: n=15; TR: n=15)</td>
<td>Training was administered intensively 2h/d, 5 days/wk, for 3 weeks. Shaping procedure was mainly used as a treatment. Beside that approximately 15 min was spent on normalisation of the muscle tone. The unaffected hand and wrist was put in a mitts, every weekday for 6h.</td>
<td>2h therapy session with emphasis on Neurodevelopmental Therapy focused on balance training, stretching, weight bearing and fine-motor tasks, ADLs.</td>
<td>Range 12 – 36 months (mean 18.7)</td>
<td>3 weeks</td>
<td>directly</td>
<td>MAL; FIM</td>
</tr>
<tr>
<td>Page et al. 2008</td>
<td>35 (mCIMT: n=13; TR: n=12; Control: n=10)</td>
<td>30 min one-on-one session of more affected arm therapy occurring 3 days per week during a 10-week period. Less affected arm was restrained (cotton hemsling) every weekday for 5h.</td>
<td>(2) Time matched rehabilitation program for the more affected arm. PNF techniques were applied for 30 min 3 days/week.</td>
<td>Range 20 – 60 months (mean 39,8 months)</td>
<td>10 weeks</td>
<td>1 week</td>
<td>ARAT, the primary outcome measure; 66-point, upper-extremity section of the FMA; MAL</td>
</tr>
</tbody>
</table>
5 Discussion

This systematic review was done in order to evaluate the effectiveness of Constraint-Induced Movement Therapy in comparison to several alternative treatment methods. It is important to state, that the conclusion is only drawn for the treatment of patients in the chronic phase of stroke.

Within this study it was decided to focus on different outcome measures (Table 3) of Constraint-Induced Movement Therapy on patients who had suffered stroke at least 6 months ago. It was able to come to a conclusion concerning dexterity and functionality, but it was not possible to come to a result for changes in strength among the patients, because only one study focused on this outcome measure (Suputtitada et al. 2004). They discovered that the mean pinch strength was statistically significantly higher in the Constraint-Induced Movement Therapy group compared to the control group.

Functionality

Functionality was evaluated by looking at the results of the Motor Activity Log (MAL) and Fugl-Meyer Assessment (FMA). It is hard to draw a clear conclusion due to the fact that the studies, which evaluated the outcome with the MAL or FMA came to contradicitive findings. Wu et al. (2007), Taub et al. (1993) as well as Page et al. (2004) found Constraint-Induced Movement Therapy (CIMT) to be more effective than traditional Therapy. On the other hand it has to be mentioned, that the two studies (van der Lee et al. 1999 & Page et al. 2008) which found no significant difference were judged highest. Therefore it can be concluded that Constraint-Induced Movement Therapy is not more effective on gains in functionality.

Dexterity

The Action Research Arm Test was the only test for dexterity that was used as an outcome measure by the included studies. When looking at the results, the outcomes again were contradicitive. Therefore drawing a clear conclusion was hard. According to the outcomes of the PEDro Scale more focus should be put on van der Lee et al. (1999) and Page et al. (2008) which scored highest. Van der Lee et al. (1999) did not find a significant difference between the intervention groups. The finding was supported by Page et al. (2004), which scored a seven on the PEDro Scale. On the other hand Page et al. (2008) found a significant difference in favour of the Constraint-Induced Movement Therapy, this finding is supported by Suputtitada et al. (2004) which only scored five on the PEDro Scale. Therefore our conclusion regarding gains in dexterity is that Constraint-Induced Movement Therapy is not more effective than traditional therapy, because more weight is put on the studies that scored higher on the PEDro Scale.

Original versus modified

All studies included used different forms of Constraint-Induced Movement Therapy (Table 2). Three of the included studies used the original Constraint-Induced Movement Therapy (Taub et al. 1993, van der Lee et al. 1999 & Suputtitada et al. 2004) and three used modified Constraint-Induced Movement Therapy (Page et al. 2004, Wu et al. 2007 & Page et al. 2008). The results suggest that the different forms of Constraint-Induced Movement Therapy do not lead to a difference between the outcomes of the study. Within studies of both intervention types positive as well as negative results of the outcome measures were shown.
Short- versus Longterm Outcomes

All included studies showed improvements for Constraint-Induced Movement Therapy and traditional therapy in the short-term. Out of these studies Taub et al. (1993), Suputtitada et al. (2004) and Wu et al. (2007) showed significant improvements in favour of Constraint-Induced Movement Therapy in the short-term. Only two (Taub et al. 1993 & van der Lee et al. 1999) of the studies included long-term follow-up’s. After the two year follow-up of Taub et al. (1993) as well as after the one year follow-up of van der Lee et al. (1999) the improvements in favour of Constraint-Induced Movement Therapy could not be maintained.

It was hypothesized, that Constraint-Induced Movement Therapy is more effective than traditional therapy in patients within the chronic phase of stroke. This hypothesis has to be rejected because it is not supported by the findings of this systematic review.

5.1 Strengths

This systematic review focuses on functionality and dexterity as well as strength level outcomes of the stroke rehabilitation therapies in patients within the chronic phase of stroke. It was able to compare a broad spectrum of different stroke rehabilitation methods to Constraint-Induced Movement Therapy. Another strength of this study is the clearly defined research question. Systematic errors were reduced by implementation of quality control measures.

5.2 Limitations

Although the database search revealed an acceptable number of randomized control trials evaluated with the PEDro scale, some of the studies failed to provide comparable follow-ups and blinding procedures. It was hard to conclude if Constraint-Induced Movement Therapy is effective or not, because of the different outcome measures used within the studies. Evaluating the effectiveness was difficult since some studies did not document all in between group outcomes. Another problem that occurred when comparing the included studies was that there were different study setups concerning Constraint-Induced Movement Therapy and traditional therapy. Within one study (Taub et al. 1993) the training time for the traditional therapy was much lower than for the Constraint-Induced Movement Therapy, so the question remains if the same amount of training could have changed the outcomes. As in earlier reviews (Bonaiuti et al. 2007) some of the studies included showed small sample sizes, and this is an important result-influencing factor.

5.3 Implication for practice

Considering the results of this review, which showed that Constraint-Induced Movement Therapy is not more effective in treating dexterity and functionality after upper-limb hemiparesis than traditional therapy, it can be stated that the use of Constraint-Induced Movement Therapy in daily practice is not advisable. Additionally, the original Constraint-Induced Movement Therapy is very time consuming and therefore is hard to administer for many practices (Page et al. 2008). Within this review no differences between the outcomes of the two Constraint-Induced Movement Therapy concepts were found, and consequently the application of modified Constraint-Induced Movement Therapy is suggested, since it is less time consuming and as a result easier to administer.
5.4 Suggestion for further research

When conducting research discussing the effectiveness of Constraint-Induced Movement Therapy, it should be emphasized on interventions with more follow-ups and blinding. Also, studies should be conducted discussing the difference between short and long term effects of Constraint-Induced Movement Therapy in comparison to traditional therapy. More focus should also be put on the long term effects, because a lot of studies only discussed the short term effects of Constraint-Induced Movement Therapy. It also would be important to conduct more studies with the same setup, so a direct comparison between the different studies can be drawn. These studies should also measure their outcomes with the same measurement tools, in order to relate the sets of data. Future studies should recruit more subjects in order to provide the study with a higher significance.

6 Conclusion

It is hard to draw a clear conclusion, due to contradictive findings within the included studies. Studies that scored lower than eight on the PEDro Scale (Taub et al. 1993, Suputtitada et al. 2004 & Wu et al. 2007), did show significant results in favour to Constraint-Induced Movement Therapy. Page et al. 2008 and van der Lee et al. 1999 do not support the findings that Constraint-Induced Movement Therapy is more effective than traditional therapy. Consequently, it can be concluded that Constraint-Induced Moment Therapy, although promising, is not more effective than traditional therapy for patients aged 45 to 85 years within the chronic phase of stroke.

7 Acknowledgements

We would like to express our thanks to J.J. Bakker who supported and lead us throughout the last months. His useful suggestions enabled us to finish our work successfully. Furthermore we want to express gratitude to the external experts, Peter Sereinigg, Dr. Ingo Heschel and Jody Bennett who provided us with their knowledge and were willing to help us answer all our questions. Additionally we would like to express our thankfulness to our client Philipp Jenny, who offered to be our client for the professional assignment project and who helped us with his knowledge about neurological patients. We are especially indebted to our families, for their mental support and advice during this straining time period.
8 References


Glossary

Allocation
The technique of forming groups in a population for the purpose of carrying out comparisons between them. The objective is to create comparable groups and to avoid bias.

Atheroma
A deposit or degenerative accumulation of lipid-containing plaques on the innermost layer of the wall of an artery.

Bias
Deviation of results or inferences from the truth, processes leading to such deviation.

Blinding
In a medical experiment the comparison of treatments may be distorted if the patient, the person administering the treatment and those evaluating it know which treatment is being allocated. It is therefore necessary to ensure that the patient and/or the person administering the treatment and/or the trial evaluators are “blind to” (do not know) which treatment is allocated to whom.

Brain stem
The part of the brain composed of the midbrain, pons, and medulla oblongata and connecting the spinal cord with the forebrain and cerebrum.

Cortical Maps
Cortical maps are collections (areas) of minicolumns in the brain cortex that have been identified as performing a specific processing function.

Delphi list
The Delphi list is a criteria list for the quality assessment of Randomized Clinical Trials for conducting systematic reviews. Developed by Delphi Consensus.

Dexterity
Readiness and grace in physical activity; especially: skill and ease in using the hands

Emboli
Plural of embolus. An embolus is something that blocks the blood flow in a blood vessel. It usually forms somewhere else and travels through the circulatory system until it gets stuck.

Functionality
The quality of being functional.

Haemorrhagic
A copious discharge of blood from the blood vessels.

Hemiplegia
Total or partial paralyses of one side of the body that results from disease of/ or injuries to the motor centers of the brain.
Hypotonia
The state of having hypertonic muscle tone.

Intention-to-treat Analysis
Is an analysis based on the initial treatment intent, not on the treatment eventually administered. This analysis is intended to avoid various misleading artifacts that can arise in intervention research.

Inter-rater reliability
Index of the consistency between two or more ratings made by separate raters. It is indexed by the correlation between the ratings of two raters.

interrupted time-series design
Type of research design suitable for either single subjects or groups in which multiple measures of the dependent variable are taken before and after some experimental manipulation. Time-series designs provide some control for history and maturation, even without the inclusion of a control group.

Intra-cerebral
Situated within, occurring within, or administered by entering the cerebrum

Ischemic
An inadequate supply of blood to a part of the body caused by partial or total blockage of an artery.

Labyrinthine reflexes
Reflexes initiated through stimulation of receptors in the utricle or semicircular canals

Neurons
Nerve cells in the brain, brain stem, and spinal cord that connect the nervous system and the muscles

Motor Cortex
The region of the cerebral cortex influencing movements of the face, neck and trunk, and arm and leg.

Motor recovery

p-value
The possibility that any particular outcome would have occurred by chance. Statistical significance is usually p< 0.05.

Paralysis
Complete or partial loss of function especially when involving the power of motion or of sensation in any part of the body.

Paresis
Slight or incomplete paralysis

Peripheral
Of, or relating to, involving, forming, or being part of the peripheral nervous system
Phylogenetic
relating to, or based on evolutionary development or history; phylogenetically adverb

Randomization
Any procedure that assigns a value or order in an unpredictable or random way such as by use of tables of random numbers. Randomisation procedures may be used for selecting subjects, assigning subjects to groups or conditions, or assigning the order in which a subject will experience a number of successive conditions.

Randomized Control Trial
An experimental comparison study in which participants are allocated via a randomization mechanism to either an intervention/ treatment group or a control/placebo group, then followed over time and assessed for the outcomes of interest. Participants have an equal chance of being allocated to either group.

Reflex inhibitory patterns

Reliability
Index of the consistency of a measuring instrument in repeatedly providing the same score for a given subject. There are many different types of reliability, each referring to a different aspect of consistency. Types of reliability include interrater reliability, test-retest reliability, and internal consistency reliability. A problem in dental therapy is that it is recovery and change that are being monitored and therefore change over time may reflect actual change, rather than unreliability of the test; this must be considered.

Significant Difference

Somatosensory deafferentation

Spasticity
Hypertonicity of muscles associated with increased tendon reflexes

Subarachnoid
The space underneath the arachnoid matter, between the arachnoid and the pia matter.

Synergies
In neurology, the faculty by which movements are properly grouped for the performance of acts requiring special adjustments

Systematic Review
A detailed structural analysis of previously conducted research.

Tone
The normal degree of vigour and tension, in muscle, the resistance to passive elongation or stretch.

Tonic reflexes
The occurrence of an appreciable interval after the production of a reflex before relaxation, e.g., the leg remains up for a time after a knee jerk.
Transcranial Magnetic Stimulation

A diagnostic tool comparable to a nerve conduction study; uses a surface magnetic impulse over a client's head, and electrical stimulation over the neck, thus resulting in stimulation of the upper motor neurons and nerve tract so that the timing of electrical impulse from the brain to the muscle can be measured. Has also been used to treat neurologic conditions, such as migraine, epilepsy, insomnia, depression, and alcoholism.
Appendix I
Mesh terms

- Hemiplegias
- Hemiplegia, Transient
- Hemiplegias, Transient
- Transient Hemiplegia
- Transient Hemiplegias
- Monoplegia
- Monoplegias
- Hemiplegia, Post-Ictal
- Hemiplegia, Post Ictal
- Hemiplegias, Post-Ictal
- Post-Ictal Hemiplegia
- Post-Ictal Hemiplegias
- Hemiplegia, Crossed
- Crossed Hemiplegia
- Crossed Hemiplegias
- Hemiplegias, Crossed
- Hemiplegia, Flaccid
- Flaccid Hemiplegia
- Flaccid Hemiplegias
- Hemiplegias, Flaccid
- Hemiplegia, Infantile
- Hemiplegias, Infantile
- Infantile Hemiplegia
- Infantile Hemiplegias
- Hemiplegia, Spastic
- Hemiplegias, Spastic
- Spastic Hemiplegia
- Spastic Hemiplegias

- Strokes
- Cerebral Stroke
- Cerebral Strokes
- Stroke, Cerebral
- Strokes, Cerebral
- Vascular Accident, Brain
- Brain Vascular Accident
- Brain Vascular Accidents
- Vascular Accidents, Brain
- Cerebrovascular Apoplexy
- Apoplexy, Cerebrovascular
- Cerebrovascular Stroke
- Cerebrovascular Strokes
- Stroke, Cerebrovascular
- Strokes, Cerebrovascular
- CVA (Cerebrovascular Accident)
- CVAs (Cerebrovascular Accident)
- Apoplexy
- Cerebrovascular Accident
- Cerebrovascular Accidents
- Stroke, Acute
- Acute Stroke
- Acute Strokes
- Strokes, Acute
- Cerebrovascular Accident, Acute
- Acute Cerebrovascular Accident
- Acute Cerebrovascular Accidents
Appendix II

ACTION

Patient Name: ____________________________

RESEARCH

Rater Name: ______________________________

ARM TEST

Date: ______________________________

Instructions

There are four subtests: Grasp, Grip, Pinch, Gross Movement. Items in each are ordered so that:

• if the subject passes the first, no more need to be administered and he scores top marks for that subtest;
• if the subject fails the first and fails the second, he scores zero, and again no more tests need to be performed in that subtest;
• otherwise he needs to complete all tasks within the subtest

Activity Score

Grasp

1. Block, wood, 10 cm cube (If score = 3, total = 18 and to Grip) _____
   Pick up a 10 cm block
2. Block, wood, 2.5 cm cube (If score = 0, total = 0 and go to Grip) _____
   Pick up 2.5 cm block
3. Block, wood, 5 cm cube _____
4. Block, wood, 7.5 cm cube _____
5. Ball (Cricket), 7.5 cm diameter _____
6. Stone 10 x 2.5 x 1 cm _____

Coefficient of reproducibility = 0.98
Coefficient of scalability = 0.94

Grip

1. Pour water from glass to glass (If score = 3, total = 12, and go to Pinch) _____
2. Tube 2.25 cm (If score = 0, total = 0 and go to Pinch) _____
3. Tube 1 x 16 cm _____
4. Washer (3.5 cm diameter) over bolt _____

Coefficient of reproducibility = 0.99
Coefficient of scalability = 0.98

Pinch

1. Ball bearing, 6 mm, 3rd finger and thumb (If score = 3, total = 18 and go to Grossmt) _____
2. Marble, 1.5 cm, index finger and thumb (If score = 0, total = 0 and go to Grossmt) _____

Coefficient of reproducibility = 0.99
Coefficient of scalability = 0.98
3. Ball bearing 2nd finger and thumb
4. Ball bearing 1st finger and thumb
5. Marble 3rd finger and thumb
6. Marble 2nd finger and thumb
Coefficient of reproducibility = 0.99
Coefficient of scalability = 0.98

**Grossmt (Gross Movement)**

1. Place hand behind head (If score = 3, total = 9 and finish)
2. (If score = 0, total = 0 and finish)
3. Place hand on top of head
4. Hand to mouth
Coefficient of reproducibility = 0.98
Coefficient of scalability = 0.97

**References**


Appendix III

Motor Activity Log

Instructions
I am going to read a list of activities to you. After each activity, I would like you to use the scales that I have placed in front of you to tell me about the use that your mother or father (or you) has in his or her involved arm for each activity that is listed. I will ask you to think about both the quality of movement and the amount of use of the involved arm. Let’s take a moment to go over the scales to make sure that you are clear about what each item on the scale means. If you don’t have any further questions, let’s begin going over the activities that are listed. We will begin by going over the activities list twice. I will ask you first to think about the amount of use of your mother or father (or yourself) involved arm 1 year ago, and then we will go through the list again, thinking about use of the involved arm 1 week ago.

For each activity the first question is:

Did you perform this activity during the past week?
If the answer is “no” the score is “not applicable”. If the answer is “yes”, the next questions are:
How much did your affected arm participate in this activity? (AOU scale)
How well did your affected arm help during this activity? (QOM scale)

Amount of Use (AOU) scale:
0. Did (does) not use the involved arm.
1. Occasionally tried (tries) to use the involved arm.
2. Used (uses) the involved arm but did (does) most of the activity with the non-involved arm.
3. Used (uses) the involved arm about half as much as normal or half as often as the non-involved arm.
4. Used (uses) the involved arm almost as much as normal.
5. Used (uses) the involved arm as much as normal.

Quality of Movement (QOM) scale
0. The involved arm was (is) never used for that (this) activity
1. The involved arm moved (moves) during the activity but was (is) of little use (very poor).
2. The involved arm was (is) of some use during that (this) activity but needed (needs) some help from the stronger arm. It moved (moves) very slowly or with difficulty (poor).
3. The involved arm was (is) used for the purpose indicated, but movements were (are) slow or were (are) made only with some effort (fair).
4. The movements made by the involved arm were (are) almost normal but not quite as fast or accurate as normal.
5. The ability to use the involved arm for that (this) activity was (is) equal to the ability to use the non-involved arm (normal).
<table>
<thead>
<tr>
<th>Sample activities</th>
<th>Yes/No/Not Applicable</th>
<th>AOU</th>
<th>QOM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steady oneself while standing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Put arm through sleeve of clothing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carry and object in hand from place to place</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eat with knife and fork</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Comb hair</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pick up cup by handle</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Handcraft/card playing/hobbies</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hold a book, journal or magazine/turn pages for reading</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use towel to dry face or other part of body</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pick up glass</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pick up tooth-brush and brush teeth</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shaving/make-up</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use key to open door</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Letter writing/typing</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**References**

