Does constraint induced movement therapy improve upper limb function following stroke?

***Prepared by*:** **Natasha Lannin,** University of Western Sydney
Belinda Armstrong, Royal Rehabilitation Centre Sydney

***Date*:** **October 2002**

Review Date: **October 2003**

Clinical Question

"What is the evidence that constraint-induced movement training of the upper limb is more effective than any other movement training for adults following stroke?"

Clinical Scenario

Constraint-induced movement therapy (CIM) is a relatively new but intense therapy protocol. Essentially a CIM approach to upper extremity therapy discourages the use of the unaffected (normal) arm and encourages the use of the hemiplegic arm in order to maximise function. What is the effectiveness of this intervention in training upper limb functional movement, and is it more effective than other movement training approaches?

Summary of Key Findings

- 36 citations were located that met the inclusion/exclusion criteria.
- 2 systematic reviews were located and appraised.
- One systematic review found small improvements in performance on the Action Research Arm test (ARA) but no improvements in functional use, and reported results in subjects ranging from 4days to 4 years post-stroke. Interpretation of results limited by lack of statistical analyses of heterogeneity.
- One systematic review found improvements in performance on the ARA, however omitted key RCTs from appraisal which limits the value of this review.
- No RCTs to date have compared CIM to MRP (or any other motor rehabilitation approach which focuses on training isolated motor control of the hemiparetic upper limb) which limits the usefulness of the systematic reviews appraised. Neither systematic review addressed cost comparisons.

Clinical Bottom Line

Constraint-induced movement therapy provides a small, positive effect (neither statistically nor clinically significant) on upper limb function in patients who require upper limb training for hemiplegia following stroke, however existing studies have only compared its effectiveness to compensatory or bimanual training techniques (and not to techniques designed to practice retraining isolated active movement in the hemiplegic arm).

Limitation of CAT

This summary of evidence has been individually prepared and has not undergone a process of peer review.

Methodology

Search Strategy
Using the levels of evidence as defined by the Oxford Centre for Evidence-based Medicine levels of evidence (Phillips, Ball, Sackett, et al., 2001), the search strategy aimed to locate the following study designs:

- Systematic reviews and meta-analyses of randomised controlled trials (level 1a);
- Systematic reviews and meta-analyses of randomised and non-randomised controlled trials (level 2a);
- Randomised controlled trials (level 1b or 2b);
- Controlled trials, cohort (level 2b) or case-control studies (level 3b);
- Case series (level 4); or
- Expert opinion including literature/narrative reviews, consensus statements, descriptive studies and individual case studies (level 5).

A search was also conducted for clinical practice guidelines based on these levels of evidence.

Search Terms
Patient/Client: stroke or neurolog$ or hemiplegi$ or CVA

Intervention: constraint or learned non-use or forced use

Comparison: *nil*

Outcomes: increased functional use, increased active movement, decreased time spent in rehabilitation program (decreased length of stay).

Sites/Resources Searched

- National Health and Medical Research Council
- New Zealand Guidelines Group
- National Guidelines Clearinghouse
- UK Guidelines: National Electronic Library for Health, Clinical Guidelines Database
- Scottish Intercollegiate Guidelines Network (SIGN)
- University of Ottawa Clinical Practice Guidelines
- Cochrane Library
- Database of Abstracts of Reviews of Effectiveness (DARE)
- PEDro – The Physiotherapy Evidence Database
- PubMed
- Medline – Pre Medline
- CINAHL
- Embase
- Journals@Ovid Full text
- Proquest Full text
- Science Citation Index and Social Sciences Citation Index
- Australasian Medical Index
- Effective Health Care Bulletins
- Centre for Clinical Effectiveness (Monash University) – Evidence Reports
- Constraint Induced Movement Therapy Online- Publications
- Joanna Briggs Institute
- GOOGLE

Inclusion/Exclusion Criteria

Inclusion Criteria

- Studies including function or movement related outcome; for example range of active movement, or performance of upper limb functional tasks.
- Studies investigating movement training post- stroke whereby the patient undergoes paretic arm training in conjunction with contralateral arm restraint.
- Studies published in English

Exclusion Criteria

- Studies which reported less than 50% or a non-defined proportion of the participants were adults who had experienced a stroke, and
- a second publication of the same study presenting the same results.

Results

Results of Search

39 relevant publications were located and categorised as follows:

Table 1. Study designs of articles retrieved by search

Methodology of Studies Retrieved	Number Located	Source of Evidence
Clinical Practice Guidelines (Evidence Based)	1	University of Ottowa Clinical Practice Guidelines
Systematic Reviews or Meta – analyses	**2**	All citations appeared in CINAHL and Constraint Induced Movement Therapy Online Publications; Medline, PubMed and PEDro also retrieved reference number 3.
Randomised Controlled Trials	4	All citations appeared in CINAHL, Embase and Constraint Induced Movement Therapy Online Publications; Medline, PubMed and PEDro also retrieved reference numbers 4,6,8.
Controlled trials or cohort studies	0	N/A
Case series: Post – test only, Pre - test/Post - test	6	Citations appeared in Medline and Pubmed (9,10,11,12,13,14,15), CINAHL (13), Embase (13), Constraint Induced Movement Therapy Online Publications (9,10,11,12,13), and Science Citation Index (9,10,11).
Expert opinion including literature/narrative reviews, consensus statements, descriptive studies and individual case studies	24	Citations appeared in Medline and Pubmed (16,17,18,19,23,24,25,27,28, 31,32,33,38,39), CINAHL (16,17,21,23,25,26,27,29,32,35,37), Constraint Induced Movement Therapy Online Publications (28,30,38,39), and GOOGLE (36, 37).

NB. Search strategy eliminated duplicates; sites were searched in the order reported on page 2.

Specific Results

The clinical guideline was based on only two of the available four RCTs at its time of writing, nor did it specify details about intervention and so was excluded from appraisal. The systematic reviews were the only studies critically appraised for this summary, as they represented next highest level of evidence. The studies and appraisal findings are summarised in Tables 2 and 3.

Table 2. Description and Appraisal of SR by van der Lee (2001)

Objective of Review
To determine whether constraint-induced movement therapy (CIM) produces greater benefit in improving upper limb function after stroke.

Methods
Data Sources – not specified.
Design of studies included – RCT (either large randomised trials or small randomised trials).
Study inclusion / exclusion criteria – not specified
Number of studies screened vs. accepted – number of studies screened not specified; three studies accepted.
Patient Population – Patients who had a stroke were included. The time since stroke ranged from 4 days to 4 years and included both inpatients and outpatients. Total number= 99 subjects at enrolment (8 dropouts across studies); 76 involved in study of chronic stroke patients (Taub et al, 1993 & Van der Lee et al, 1999), 23 subjects involved in study of acute stroke patients.
Data Extraction: Adult stroke patients given constraint-induced movement therapy, tests of upper limb function.
Analysis –data synthesis limited; Outcomes of continuous data were analysed as the difference in standardised mean scores with 95% confidence limits between intervention and control. No testing for heterogeneity. Author does not report on the validity of included studies.
Outcomes – primary outcome: motor function (Action Research Arm Test (ARA)); secondary outcome: ability of an individual to perform activities of daily living.
Follow-up – two studies (Taub et al, 1993 & Van der Lee et al, 1999) provided follow-up period post-intervention; drop-out rates to obtaining follow-up of primary outcome data ranged from 6% to 13% across studies.

Results
SR did not calculate effect sizes due to insufficient data presentation and baseline difference between groups. Intensity of therapy: control groups received 2 to 6 hours per day of bimanual occupational therapy training; intervention patients received 6 hours per day of constraint (plus 2 hours occupational therapy focused on retraining upper limb function in the Dromerick et al, 2000 study). Standardised Mean Difference for ARA scores: 0.341 (-0.16 to 0.84) (Van der Lee et al, 1999); 0.45 (-0.44 to 1.34) (Dromerick et al, 2000). Effect sizes of standardised mean differences (in contrast to individual papers' reporting of results) do not reach statistical significance as demonstrated by the 95% CI which contain 0.

Authors Conclusions
The evidence in favour of CIM at this time is not decisive, is level II at the most, and may not be specific for CIM, but may be caused by the more intensive training.

Reviewer Appraisal Comments

Validity (Methodology, rigour, selection, biases)

- A focused clinical question was addressed by the reviewer.
- No details of the methods used to select studies for inclusion or to extract data are reported. Reviewer's own search (up to year 2000) yielded identical results; however a new RCT was published after this date which was not included in the review (Page, Sisto, Leine, Johnston & Hughes, 2001) which poses the threat that a relevant study which would change the overview's conclusion was omitted.
- There is no assessment of validity of the included studies.
- There is no statistical assessment of heterogeneity among trials.
- Follow-up varied between trials (ranged from 0 to 2 years-post). All patients recruited to the included studies were accounted for at post-intervention (total of 8 drop-outs) however no study used intention-to-treat analysis.

Results (Favourable or unfavourable, specific outcomes of interest, size of treatment effect, stat. and clinical significance)

- Statistical analysis provided for standardised mean difference (SMD) between improvement in both groups immediately post-intervention only. Missing data from Taub et al, 1993 did not allow comparison across all three included studies; and differences in time post-stroke results in methodological difficulties in combining the effects of treatment across studies.
- Reviewer aware that the ARA scores a maximum of 57 points and that the average baseline score on ARA was 29 points (across two of the included studies). However, no information on the magnitude of a minimally important difference is provided which complicates interpretation of the reported SMD for each study. (Previous research has used minimal clinically difference of 5.7 points. SR reported a difference of 3.4)
- No information on program costs provided.

Table 3. Description and Appraisal of SR by Dickson (2002)

Objective of Review
To determine what evidence there is for traditional and contemporary approaches to motor control following stroke for occupational therapists (included assessment of constraint-induced movement therapy as one therapy technique within the review).

Methods
Data Sources – Cochrane Library, MEDLINE and CINAHL databases and hand searches of "relevant publications" (no further details specified).
Design of studies included – systematic reviews, RCT (either large randomised trials or small randomised trials), repeated measures designs.
Study inclusion / exclusion criteria – not specified.
Number of studies screened vs. accepted – number of studies screened not specified, one study accepted.
Patient Population – Patients who had a stroke were included. The time since stroke was not specified within review. Total number of patiens within CIM trial= 23 subjects at enrolment (3 dropouts).
Data Extraction: Adult stroke patients given constraint-induced movement therapy, tests of upper limb function.
Analysis –data synthesis not completed; No testing for heterogeneity. Author does not report on the validity of included study. Only "vote-counting" was completed.
Outcomes – primary outcome: motor function (Action Research Arm Test (ARA)); secondary outcome: ability of an individual to perform activities of daily living (FIM upper limb items; Barthel Index).
Follow-up – no follow-up period post-intervention; drop-out rates to obtaining primary outcome data post-intervention was 13%.

Results
SR did not calculate effect sizes. …"this study, involving 23 patients, did indicate that less arm impairment was seen inpatients receiving constraint-induced movement therapy. However, there was no significant difference in the patient's performance of activities of daily living." (Dickson, 2002; pp271).

Authors Conclusions
There is only limited evidence to support the use of new approaches (constraint-induced movement therapy) for rehabilitation of motor control following stroke.

Reviewer Appraisal Comments

Validity (Methodology, rigour, selection, biases)
- A focused clinical question was addressed by the reviewer.
- No details of the methods used to select studies for inclusion or to extract data are reports. Reviewer's own search yielded larger number of trials and systematic reviews on CIM which were not included in this study. Therefore there is the possibility that a relevant study which would change the overview's conclusion was omitted.
- There is no assessment of validity of the included studies.
- There is no statistical assessment of heterogeneity among trials.

Results (Favourable or unfavourable, specific outcomes of interest, size of treatment effect, stat. and clinical significance)
- There is no statistical analysis provided for included study, nor any reporting of effects reported in original paper.
- No information on program costs provided.

References

1. Phillips B, Ball C, Sackett D, Badenoch D, Straus S, Haynes B, Dawes M. (1998). Levels of evidence and grades of recommendations. http://cebm.jr2.ox.ac.uk/docs/levels.html Accessed on 6/07/2001.

Articles critically appraised for this summary of evidence

Level Ia Evidence

2. Van der Lee JH. (2001). Constraint-induced therapy for stroke: more of the same or something completely different? *Current Opinion in Neurology, 14*(6):741-744.

Level IIa Evidence

3. Dickson M. (2002). Rehabilitation of motor control following stroke: searching the evidence. *British Journal of Occupational Therapy, 65*(6):269-274.

Related articles not included in the appraisal

Evidence Based Guideline

4. Teasell R,Doherty T, Speechley M, Foley N, & Bhogal SK. (2002). Evidence Based Review of Stroke Rehabilitation. Retrieved October 23, 2002, from http://www.sjhc.london.on.ca/parkwood/ebrsr/ebrsr.htm

Level Ib Evidence

5. Van der Lee JH, Wagenaar RC, Lankhorst GJ, Vogelaar TW, Deville WL, Bouter LM. (2000). Forced use of the upper extremity in chronic stroke patients: results from a single-blind randomized clinical trial. *Stroke, 30*(11):2369-2375.

Level IIb Evidence

6. Dromerick AW, Edwards DF, Hahn M. (2000). Does the application of constraint induced movement therapy during acute rehabilitation reduce arm impairment after stroke? *Stroke, 31*(12):2984-2988.
7. Page SJ, Sisto SA, Levine P, Johnston MV, Hughes M. (2001). Modified constraint-induced therapy: a randomised feasibility and efficacy study. Journal of Rehabilitation Research and Development, 38(5): 583-590.
8. Taub E, Miller NE, Novack TA, Cook EW, Fleming WC, Nepomuceno CS, Connell JS, Crago JE. (1993). Technique to improve chronic motor deficit after stroke. *Archives of Physical Medicine and Rehabilitation, 74*(4):347-354.

Level III Evidence

Level IV Evidence

9. Kopp B, Kunkel A, Muhlnickel W, Villringer K, Taub E, Flor H.(1999). Plasticity in the motor system related to therapy-induced improvement of movement after stroke. Neuroreport, 10:807-810.
10. Kunkel A, Kopp B, Muller G, Villringer K, Villringer A, Taub E, Flor H. (1999). Constraint-induced movement therapy for motor recovery in chronic stroke patients. *Archives of Physical Medicine and Rehabilitation, 80*(6):624-628.
11. Levy CE, Nichols DS, Schmalbrck PM, Keller P, Chakeres DW. (2001). Functional MRI evidence of cortical reorganisation in upper-limb stroke hemiplegia treated with constraint-induced movement therapy. *American Journal of Physical Medicine and Rehabilitation, 80*(1):4-12.
12. Liepert J, Bauder H, Wolfgang HR, Miltner WH, Taub E, Weiller C. (2000). Treatment-induced cortical reorganisation after stroke in humans. *Stroke, 31*(6):1210-1216.
13. Liepert J, Uhde I, Graf S, Leidner O, Weiller C. (2001). Motor cortex plasticity during forced-use therapy in stroke patients: a preliminary study. *Journal of Neurology, 248*(4): 315-321.
14. Miltner WH, Bauder H, Sinner Nm Dettmers C, Taub E. (1999). Effects of constraint-induced movement therapy on patients with chronic motor deficits after stroke: a replication. *Stroke, 30*(3):586-592.
15. Wolf SL, Lecraw DE, Barton LA, Jann BB. (1989). Forced use of hemiplegic upper extremities to reverse the effect of learned nonuse among chronic stroke and head-injured patients. *Experimental Neurology, 104*(2): 125-132.

Level V Evidence

16. Benevento A. (1998). Successful outcome sin stroke following forced use: what are the contributing factors? *Occupational Therapy in Health Care, 11*(2): 59-76.

17. Blanton S, Wolf SL. (1999). An application of upper extremity constraint-induced movement therapy in a patient with subacute stroke. *Physical Therapy, 79*(9):847-853.
18. Freeman E. (2001). Unilateral spatial neglect: new treatment approaches with potential application to occupational therapy. *American Journal of Occupational Therapy, 55*(4):401-408.
19. Liepert J, Miltner WH, Bauder H, Sommer M, Dettmers C, Taub E, Weiller C. (1998). Motor cortex plasticity during constraint-induced movement therapy in stroke patients. *Neuroscience Letters, 250*(1):5-8.
20. Miller KJ, Garland SK, Koshland GF. (1998). Techniques and efficacy of physiotherapy poststroke. *Physical Medicine and Rehabilitation: State of the Art Reviews, 12*(3):473-487.
21. Morris DM, Taub E. (2001). Constraint0induced therapy approach to restoring function after neurological injury. *Topics in Stroke Rehabilitation, 8*(3): 16-30.
22. Nudo RJ, Friel KM. (1999). Cortical plasticity after stroke: implications for rehabilitation. *Revue Neurologique, 155*(9):713-717.
23. Ostendorf CG, Wolf SL. (1981). Effect of forced-use of the upper extremity of a hemiplegic patient on changes in function. *Physical Therapy,61*(7):1022-1028
24. Page SJ, Levine P, Sisto S, Bond Q, Johnston MV. (2002). Stroke patients' and therapists' opinions of constraint-induced movement therapy. *Clinical Rehabilitation, 16*(1):55-60.
25. Page SJ, Sisto S, Johnston MV, Levine P, Hughes M. (2002). Modified constraint-induced therapy in subacute stroke: a case report. *Archives of Physical Medicine and Rehabilitation, 83*(2):286-290.
26. Russo SG. Hemiplegic upper extremity rehabilitation: a review of the forced-use paradigm. *Neurology Report, 19*(1):17-22.
27. Sabari JS, Kane L, Flanagan SR, Steinberg A. (2001). Constraint-induced motor relearning after stroke: a naturalistic case report. *Archives of Physical Medicine and Rehabilitation, 82*(4):524-528.
28. Sathian K, Greenspan AI, Wolf SL. (2000). Doing it with mirrors.: a case study of a novel approach to neurorehabiliation. *Neurorehabilitation and Neural Repair, 14*(1):73-76.
29. Schaumberg S, Pierce S, Shuter L, Gershkoff A. (1999). Two hands are better than one: constraint induced therapy can help stroke survivors regain power in the involved arm. *Advance for Directors in Rehabilitaiton, 8(*10):43-45.
30. Shepard B. (2000). New Strategies after stroke: restraining, rewiring, relearning. UAB Magazine, 20(1):1-4.
31. Sisto SA, Page SJ, Johnston MV. (2000). Changes in upper limb motion measured by accelerometers in stroke after constraint-induced therapy. *Archives of Physical Medicine and Rehabilitation, 81*(12):1622.
32. Taub E, Morris DM. (2001). Constraint-induced movement therapy to enhance recovery after stroke. *Current Atherosclerosis Reports, 3*(4):279-286.
33. Taub E, Crago JE, Morris DM. (2002). Constraint-induced movement therapy: clinical applications. Retrieved 8 October, 2002 from http://www.apta.org/programming/handouts/pt2002/3089.pdf
34. Taub E, Uswatte G, Pidikiti R. (1999). Constraint-induced movement therapy: a new family of techniques with broad application to physical rehabilitation- a clinical review. *Journal of Rehabilitation Research and Development, 36*(3):237-251.
35. Taub E, Wolf SL. (1997). Constraint-induced movement techniques to facilitate upper extremity use in stroke patients. *Topics in Stroke Rehabilitation, 3*(4):38-61.
36. Taub E, Uswatte G. (2000). Constraint-induced movement therapy and massed practice. *Stroke, 31*:983.
37. Uswatte G, Taub E. (1999). Constraint-induced movement therapy: new approaches to outcome measurement in rehabilitation. In: DT Stuss, G Winocur, & IH Robertson. *Cognitive Rehabilitation*. Cambridge: Cambridge University Press: 215-229.
38. van der Lee, Beckerman H, Lankhorst GJ, Bouter LM, Blanton S, Wolf SL. (2000). Constraint induced movement therapy [Letters to the Editor]. *Physical Therapy, 80*(7): 711-713.
39. van der Lee, Beckerman H, Lankhorst GJ, Bouter LM, Flor H, Kopp B, Kunkel A, Taub E. (1999). Constraint-induced movement therapy [Letters to the Editor]. *Archives of Physical Medicine and Rehabilitation, 80*(12):1606-1607.