Does bilateral upper limb training improve upper limb function following stroke?

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Clinical Question

What is the evidence that bilateral training of the upper limb is more effective than any other movement therapy for adults following stroke?

Clinical Scenario

The use of bilateral training techniques with the upper limb following stroke has been advocated recently as new theories of neural plasticity have developed. What is the evidence that this training technique improves functional movement?

Summary of Key Findings

- 6 citations were located that met the inclusion/ exclusion criteria.
- 2 studies (one small RCT with design flaws and one controlled cohort study) were located and appraised.
- The RCT found the use of a single session of massed bilateral practice led to no statistically significant increase in muscle activity for either shoulder abduction or wrist extension in the densely hemiplegic patient.
- The controlled cohort study found that bilateral training was not more effective than unilateral training in improving accuracy or speed of upper limb movements in patients with complete or almost complete recovery from hemiparesis.
- Neither study measured change in ability to perform functional tasks following bilateral training.

Clinical Bottom Line

Bilateral upper limb training does not have a statistically or clinically significantly greater impact on upper limb motor recovery following stroke than other movement therapies for those with dense hemiplegia or near-complete to complete recovery from hemiplegia, however existing studies of good quality have not examined its impact on those with moderate hemiplegia.

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 Ia);
- Systematic reviews and meta-analyses of randomised and non-randomised controlled trials (level IIa);
- Randomised controlled trials (levels Ib or IIb);
- Controlled trials or cohort studies (level Ib);
- Case control studies (level IIIb);
- Case series (level IV); or
- Expert opinion, including literature/ narrative reviews, consensus statements, descriptive studies and individual case studies (level V).

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

Search Terms:

Patient/Client: cerebrovascular accident or stroke or neurolog$ or hemiplegi$ or CVA

Intervention: bilateral or bilateral isokinematic training or BIT or entrainment

Comparison: Nil

Outcomes: increased active movement, increased functional use, 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)
- Cochrane Library
- Database of Abstracts of Reviews of Effectiveness (DARE)
- Physiotherapy Evidence Database (PEDro)
- Medline- Pre Medline
- CINAHL
- EMBASE
- Journals @ Ovid Full text
- Effective Health Care Bulletins
- Centre for Clinical Effectiveness (Monash University) – Evidence Reports
- Joanna Briggs Institute

Inclusion/Exclusion Criteria

Inclusion Criteria

- Studies including movement or function of the upper limb related outcome. Eg. Active range of motion, or performance of upper limb functional tasks.
- Studies investigating the effectiveness of bilateral training techniques for hemiparetic upper limb training following stroke.
- Studies published in English.

Exclusion Criteria

- Studies investigating the use of specific outcome measures or assessments, rather than the effectiveness of bilateral training techniques, for upper limb training following stroke.
- Studies examining the quantity or quality of upper limb entrainment with bilateral movement, rather than the effectiveness of bilateral training techniques following stroke.
- Studies investigating bilateral movement training combined with other upper limb training techniques.

Results

Results of Search

Six relevant studies 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)	0	N/A
Systematic Reviews or Meta-analysis	0	N/A
Randomised Controlled Trials	**1**	**CINAHL, Medline and EMBASE**
Controlled trials or cohort studies	**1**	**Medline**
Case series Post-test only, Pre-test/ post-test	4	Citations appeared in Medline (5, 6, 8), and CINAHL (6, 7, 8)
Expert opinion including literature/narrative reviews, consensus statements, descriptive studies and individual case studies	0	N/A

Specific Results

The randomised controlled trial had a small number of subjects and contained methodological flaws, and were therefore of the same level of evidence as the controlled cohort study (IIb). The randomised controlled trial and controlled cohort study were the only studies critically appraised for this summary, as they represent higher levels of evidence. The studies and appraisal findings are summarised in Tables 2 and 3.

Table 2. Description and Appraisal of RCT by Mudie & Matyas (2001)

Objective of Study
To determine the extent to which Bilateral Isokinematic Training (BIT) could elicit movement in the densely hemiplegic upper extremity, and the extent to which these improvements are generalised to subsequent unilateral performances. To compare the practice effects on distal and proximal muscle groups and determine if bilateral practice is more beneficial in the acute or chronic phase of stroke.

Intervention Investigated
Single thirty-minute session containing 5 trials of 5 exercise repetitions each (=25 exercises). Both wrist extension and shoulder abduction were practiced in supine with a target to aim towards. The acute experimental (n=9), chronic experimental (n=9), acute control (n=9) and chronic control (n=9) groups performed trials 1, 3 and 5 with the hemiplegic upper limb only. The acute experimental and chronic experimental groups performed trials 2 and 4 bilaterally, while the acute control and chronic control groups performed trial 2 unilaterally and trial 4 bilaterally.

Primary Outcome Measures
Muscle activity of the middle deltoid for arm abduction and the extensor carpi radialis longus (ECRL) for wrist extension, was measured with EMG during attempted isometric contractions. EMG recordings were taken for each of the five exercise repetitions in each of the five trials

Results
No statistically significant difference (when $p < 0.05$. NB: no power calculations included in paper) was found between bilateral and unilateral EMG levels for either shoulder abduction or wrist extension. There was no statistically significant generalisation effect seen for either shoulder abduction or wrist extension following bilateral practice. Although results favoured the improved performance of chronic subjects, there was no statistically significant difference between the chronic and acute groups. The differences in responses of proximal and distal muscles were not statistically significant.

Authors Conclusions
Small increases in muscle activity were evident following bilateral practice, although they were not significantly significant. Given that previous studies have had positive findings, and the design flaws of this study, particularly the use of a single session of massed practice, no decisions should be made regarding the efficacy of bilateral training techniques in the hemiplegic upper limb following stroke until further research is conducted.

Reviewer Appraisal Comments

Validity (Methodology, rigour, selection, bias)

- Participants in the chronic groups were recruited from individuals who had contacted the chief investigator after publicity about her former research in the media. Treating clinicians in two rehabilitation centres referred participants in the acute groups. Both recruitment methods subject to selection bias.
- Participants assigned to the experimental or control groups through random allocation.
- No details of random allocation process provided.
- Participant eligibility criteria established and groups found to be matched for gender, age, length of time since stroke and extent of hemiplegia on statistical analysis.
- No information provided re blinding of researchers or subjects.
- No information of subject drop-outs provided.
- No information regarding concurrent treatments provided.
- No power calculation provided, so cannot comment on adequacy of the sample size.

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

- Both within-subject and between-groups differences calculated.
- No confidence intervals provided for estimation of the size of the treatment effect between a) the acute experimental group and the acute control group and b) the chronic experimental group and the chronic control group. These have been estimated as follows:

  - Changes in hemiplegic upper extremity shoulder abduction in trial 2:
    Acute experimental group and acute control group: Size of treatment effect is 2.64 iEMG*, (95%CI = 0.05 to 5.23)*
    Chronic experimental group and chronic control group: Size of treatment effect is 0.88 iEMG*, (95% CI = -1.41 to 3.17)*

  - Changes in hemiplegic upper extremity wrist extension in trial 2:
    Acute experimental group and acute control group: Size of treatment effect is 2.4 iEMG*, (95%CI = -0.76 to 5.56)*
    Chronic experimental group and chronic control group: Size of treatment effect is 1.44 iEMG*, (95% CI = -3.01 to 5.89)*

- iEMG measurements are arbitrary, however author suggests that “in the case of attempts at isometric contraction (as in this study) we would have expected the increase in muscle activity shown in BIT to be sustained in the post-practice unilateral attempt. In other words 100% of EMG activity gained during BIT should be present in the post-practice unilateral attempt… Thus an acceptable clinically important change would be 100% carry over of the bilateral practice gain to unilateral practice.” (H. Mudie, Personal Communication, 7 May 2003)
- No link made between EMG measurement to gains in functional use of the upper limb or discussion of the functional implications of increased EMG muscle activity.

*Reviewer calculations. The confidence interval for the difference between two means uses the method that assumes equal variances for the two populations (Armitage & Berry, 1994).

Table 3. Description and Appraisal of controlled cohort by Platz, Bock & Prass (2001)

Objective of Study
To examine the level of skilfulness among functionally recovered hemiparetic patients and determine if this degree of skilfulness in aimed movements can be improved with training. To determine if training of the affected limb alone, or simultaneously and symmetrically with the unaffected limb, modifies the gains in motor learning.

Intervention Investigated
The experimental group received arm ability training using three training tasks based on an "Arm Ability Training" method. These exercises were 1) Fast and accurate aiming movement 2) fast tapping with the index finger and 3) pick up and place small wooden sticks on top of each other, with a focus on dexterity and aiming.

Primary Outcome Measures
Three motor tasks (Unilateral aiming (single unilateral task), bilateral aiming (single bilateral task), and contralateral triangular movement of index finger of one hand in conjunction with aiming with the other hand (dual task)) were analysed kinematically in 3D using an infrared system (SELSPOT II) to measure:

1. Spatial accuracy (at both the end of the first movement phase and at the end of movement)
2. Movement time (total movement time, and duration of first and second movement phases)

The control group (n=14) were measured once. The experimental group (n=14) were measured one day before and one day after the five consecutive day intervention period.

Results

Accuracy
Accuracy of aiming movements remained stable without statistically significant effects (when $p<0.05$) of training, type of training (unilateral or bilateral) or task condition (single or dual task).

Speed
Average movement time for aimed movements (both single and dual) and both experimental groups (unilateral and bilateral training) decreased after training ($p = 0.0061$), especially for single tasks ($p = 0.0055$). In the single task group slower baseline measures were an indicator of greater improvement ($p = 0.0019$). In both unilateral and bilateral training conditions the first movement phase became quicker after training.

Type of Training
The type of training (unilateral, bilateral or dual task) did not significantly influence the effects of training. In all groups, individuals variability in performance decreased after training ($p = 0.0087$). Type of training (unilateral or bilateral) had only a limited modifying effect on outcome ($F(1.11)$,1.0); if anything, the unilateral training was somewhat more efficacious in improving the more ballistic component of aimed movements ($p = 0.1252$).

Authors Conclusions
Reduced skilfulness can be improved by a structured training specifically addressing deficient motor abilities even when baseline motor control performance is already at a high level. There was nothing to indicate bilateral training would result in a more favourable outcome. Overall, results indicate that to improve aiming ability in high functioning hemiparetic patients a unilateral training program is effective.

Reviewer Appraisal Comments

Validity (Methodology, rigour, selection, biases)

- Experimental group participants were selected from an in-patient population at a University hospital.
- Control group participants were matched for age, gender and educational level and randomly assigned to a subgroup performing the experimental tasks with their right arm or their left arm (to correspond with left and right hemispheric stroke patients in the experimental group. No description of this random allocation procedure was given.
- No information provided re blinding of researchers or participants, it is therefore assumed that this blinding did not occur.
- No drop out rate information was provided.
- All participants were treated in the same way apart from the intervention under investigation.
- No power calculation provided, so cannot comment on adequacy of the sample size.

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

- Standard deviations were not provided for before and after scores, therefore confidence intervals unable to be determined.
- Outcome measures used very small units (eg: speed in milliseconds and accuracy in millimetres), which limits clinical and functional significance of change.
- Results not linked to functional use of upper limb.

References

1. Phillips, B., Ball, C., Sackett, D., Badenoch, D., Straus, S., Haynes, B., & Dawes, M. (1988). Levels of evidence and grades of recommendations. http://cebm.jr2.ox.ac.uk/docs/levels.html Accessed on 24/03/2003

2. Armitage, P. & Berry, G. (1994). Statistical Methods in Medical Research. (3rd ed.). London: Blackwell, pp. 109. www.pedro.fhs.usyd.edu.au. Accessed on 29/04/2003

Articles critically appraised for this summary of evidence

Level IIb Evidence

3. Mudie, M.H. Matyas, T.A. (2001). Responses of the densely hemiplegic upper extremity to bilateral training. Neurorehabilitation and Neural Repair, 15:129-140

4. Platz, T., Bock, S. & Prass, K. (2001). Reduced skilfulness of arm motor behaviour among motor stroke patients with good clinical recovery: Does it indicate reduced automaticity? Can it be improved with unilateral or bilateral training? A kinematic motion analysis study. Neurophysychologica, 39:687-698

Related articles not included in the appraisal

Level IV Evidence

5. Cunningham, C.L., Phillips Stoykov, M.E. & Walter, C.B. (2002). Bilateral facilitation of motor control in chronic hemiplegia. Acta Psychologica, 110:321-337

6. Mudie, M.H. & Matyas, T.A. (2000). Can simultaneous bilateral movement involve the undamaged hemisphere in reconstruction of neural networks damaged by stroke? Disability and Rehabilitation, 22(1/2):23-37

7. Mudie, M.H. & Matyas, T.A. (1996). Upper extremity retraining following stroke: Effects of bilateral practice. Journal of Neurologic Rehabilitation, 10(3):167-184

8. Whitall, J., McCombe Waller, S., Silver, K.H.C. & Macko, R.F. (2000). Repetitive bilateral arm training with rhythmic auditory cueing improves motor function in chronic hemiparetic stroke. Stroke, 31:2390-2395