Strength training improves upper-limb function in individuals with stroke: a meta-analysis

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CRD summary
This review concluded that strength training can improve upper-limb strength and function without increased tone or pain in individuals with stroke. A lack of high-quality trials, the small sample sizes and potential for bias made the reliability of the authors' conclusions unclear.

Authors' objectives
To assess the evidence for strength training of the paretic upper limb in improving strength, upper-limb function and activities of daily living (ADL) in people with stroke.

Searching
Cochrane Database of Systematic Reviews, MEDLINE, CINAHL, EMBASE and PEDro were searched for English-language studies published in peer-reviewed journals from 1950 to April 2009; search terms were reported. Additional studies were sought through handsearches of relevant journals and reference lists from systematic reviews.

Study selection
Randomised controlled trials (RCTs) in adult patients with a confirmed diagnosis of stroke (by computed tomography, magnetic resonance imaging or clinical examination) that assessed the effect of a graded strengthening programme compared with unidimensional or multidimensional programmes were eligible for inclusion. Evaluation of upper-limb strength, upper-limb function (for example, Action Research Arm Test) or ADLs were required for inclusion. Studies had to be compared with a control group comprised either no treatment, placebo or a non-strengthening intervention. One arm of the trial had to include a component of strength/resistance training as an element of the intervention. Experimental and comparison group treatments had to be clearly defined. Strength training was defined as an intervention that incorporated voluntary active exercises against resistance by using resistance bands, weights or gravity-resisted exercises. Exercises could be isometric, isotonic or isokinetic. Excluded studies assessed repetitive practice (with no resistance), constraint-induced movement therapy, robot-assisted therapy or electrical stimulation.

In the included studies, where stated, mean age ranged from 46 to 74 years of age and time since stroke ranged from two weeks to 5.1 years. Most of the included studies assessed isotonic exercises with resistance bands and free weights. Treatment was typically of one hour per day on two to three days per week over four weeks. One third of studies had programmes that lasted between 10 and 19 weeks. Several studies used an upper-limb programme as the control group when investigating a lower-limb training programme. Prescribed out-patient treatment was used in studies that investigated upper-limb training. Neurodevelopmental treatment techniques were used as control group in several studies.

Two reviewers independently selected studies for inclusion in the review. Disagreements were resolved through consultation with a third reviewer.

Assessment of study quality
Quality of the RCTs was assessed using the 10-item PEDro scale (maximum score 10).

The authors did not state how many reviewers performed quality assessment.

Data extraction
For continuous outcomes, mean differences and standard deviations in each group were extracted and standardised mean differences (SMD) with 95% confidence intervals (CIs) were calculated. Where mean differences and standard deviations were not reported, estimates were calculated from medians and inter-quartile ranges using the methods of Hozo et al.
The authors did not state how many reviewers performed data extraction.

**Methods of synthesis**

Pooled SMDs and 95% CI were calculated using a random-effects model. The $\Gamma^2$ test was used to evaluate statistical heterogeneity. A priori subgroup analysis was performed for duration of injury after stroke (sub acute six months versus chronic six months) and level of upper-limb motor impairment (moderate and mild) determined by using impairment outcomes measured at baseline (for example, Fugl-Meyer or grip strength). Sensitivity analysis was undertaken by comparing random-effect models with fixed-effect models and examining the impact of removing low-quality studies (<5 on the PEDro scale). Funnel plots were used to detect possible publication bias.

**Results of the review**

A total of 13 RCTs (n=569, range 12 to 100) were included in this review. PEDro scores ranged from 2 to 8: three studies scored 7, four scored 8 and six studies scored between 2 and 5. There was a discrepancy in patient numbers between the tables and the text.

A significant effect for strength training was found for grip strength (SMD 0.95, 95% CI 0.05 to 1.85, $\Gamma^2=91\%$; six studies) and upper-limb function (SMD 0.21, 95% CI 0.03 to 0.39, $\Gamma^2=0\%$; 11 studies).

A significant effect for strength training on upper-limb function was found for studies that included subjects with moderate (SMD 0.45, 95% CI 0.05 to 0.84, $\Gamma^2=53\%$; five studies) and mild (SMD 0.26, 95% CI 0.08 to 0.61, $\Gamma^2=33\%$; six studies) upper-limb motor impairment.

No treatment effect was found for strength training on measures of activities of daily living (five studies).

General conclusions and magnitude of treatment effect were unchanged by sensitivity analysis.

Adverse effects (six studies). None of the studies that assessed increased tone (three studies) and increased pain (four studies) reported any significant difference between intervention and control groups.

**Authors’ conclusions**

There was evidence that strength training can improve upper-limb strength and function without increasing tone or pain in individuals with stroke.

**CRD commentary**

The review addressed a clear question and was supported by appropriate inclusion criteria. Attempts to identify relevant studies were undertaken by searching electronic databases and checking references, but the restriction to English-studies and exclusion of unpublished studies meant that relevant studies may have been missed and the review may have been subject to publication and language biases. Suitable methods were employed to reduce risks of reviewer error and bias during study selection; the authors did not report on whether such methods were used to assess quality and extract data. An appropriate assessment of quality of included studies was undertaken and the results were used in the sensitivity analyses. Just under half of the included trials were considered to be of poor quality, but it was unclear which criteria the studies failed to report as detailed findings were not presented. Most studies had small sample sizes. The synthesis using meta-analysis appeared appropriate and an assessment of heterogeneity was undertaken. Sensitivity and subgroup analyses were conducted in an attempt to investigate heterogeneity. The authors acknowledged that it was difficult to isolate the effect of strength training in the six studies in which strength training was only one component of the intervention. A lack of high-quality trials, the small sample sizes and potential for bias made the reliability of the authors’ conclusions unclear.

**Implications of the review for practice and research**

**Practice:** The authors did not state any implications for practice.

**Research:** The authors stated that future trials should assess intensity frequency, and specificity of strength training required for improved performance in daily activities. Studies were also required to compare strength training with other specific upper-limb treatments.
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Hozo SP, Djulbegovic B, Hozo I. Estimating the mean and variance from the median, range, and the size of sample. BMC Medical Research Methods 2005; 5:01-10.

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