Impact of EMG-triggered neuromuscular stimulation of the wrist and finger extensors of the paretic hand after stroke: a systematic review of the literature

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CRD summary
This review found no significant differences in hand function of post-stroke patients treated with electromyography-triggered neuromuscular electrical stimulation of the wrist and finger extensor muscles. The poor methodological quality of the included trials mean that it is difficult to draw conclusions about the reliability of the authors’ conclusions.

Authors’ objectives
To assess the effectiveness of electromyography-triggered neuromuscular electrical stimulation to the extensor muscles of the forearm in improving hand function in patients after stroke.

Searching
PubMed, Cochrane Central Register of Controlled Trials (CENTRAL), CINAHL, DARE, the Physiotherapy Evidence Database, EMBASE, DocOnline and HighWire were searched up to June 2006 for relevant articles in English, German or Dutch languages. Search terms were reported. Reference lists of relevant studies were searched for additional articles.

Study selection
Randomised controlled trials (RCTs) that assessed the effects of electromyography-triggered neuromuscular electrical stimulation (by means of surface electrodes) to activate the extensor muscles of the forearm, compared with usual care, in patients diagnosed with a stroke were eligible for inclusion. The definition of a stroke was a focal (at times global) neurological impairment of sudden onset and lasting more than 24 hours and of presumed vascular origin (as used by the World Health Organisation).

Most of the included trials investigated treatment effects during the chronic post-stroke phase. Patients either had no stroke history, or were assessed between 16.5 days and 4.73 years since their stroke. The mean age of the patients ranged between 54.48 and 69.6 years. The stimulation devices used included the Automove 800, the Automove AM 706 and the Neumove microprocessor. Most of the studies used a frequency of 50Hz; other studies used frequencies ranging from 20 to 100Hz; amplitudes ranged from zero to 60mA. The electromyography-triggered neuromuscular electrical stimulation interventions took place over time periods that ranged from two to 12 weeks, with treatment durations of 30 to 90 minutes, two to three times per day, and between three to seven days per week. The comparators were no stimulation, usual treatment, and the use of exercise in combination with electrical stimulation or movement imagery. The outcomes assessed were those relating to upper limb and hand function including the Fugl-Meyer Motor Assessment Scale for the upper extremity, the Action Research Arm Test Box and Block timed manipulation test, reaction time, and the ability to maintain sustained contractions.

The authors did not state how many reviewers performed the study selection.

Assessment of study quality
Two reviewers independently assessed the methodological quality of the included trials using the PEDro scale in terms of one item relating to external validity, and 10 items relating to internal validity (random allocation, allocation concealment, blinding, patient similarity at baseline, follow-up, the use of intention-to-treat analyses and outcome measurement). A score out of a maximum 10 points was calculated for each study. Inter-rater agreement was assessed by calculation of Cohen’s Kappa score and any disagreements between the reviewers were resolved by discussion.

Data extraction
Means and standard deviations were extracted from individual trials to calculate effect sizes using the Hedges g-model. In the event of missing data from a trial, the authors were contacted.
The authors did not state how many reviewers performed the data extraction.

**Methods of synthesis**

Statistical pooling was considered if the PEDro scores for methodological quality were 3 or more out of 10 points. Pooled effect sizes and corresponding 95% confidence intervals (CI) were calculated using the Hedges' g fixed-effect model. The pooling was weighted by sample size. Heterogeneity between the pooled studies was tested by the Q-statistic and examined by the $I^2$ test. In the event of statistical heterogeneity, a random-effects model was used to combine the study results.

Sensitivity analyses were performed to remove trials that were significantly heterogeneous.

**Results of the review**

Eight RCTs ($n=157$ patients) were included in the review. The sample sizes in the studies ranged between nine to 27 patients. The median PEDro score was 5 points, ranging from 2 to 6 points, indicating low methodological quality. None of the studies used intention-to-treat analyses and the randomisation procedure was concealed in three trials. The Kappa score for all PEDro items was 0.83. There were some discrepancies in the figures presented in the forest plots and the text; the figures presented below were taken from the forest plots.

There were no significant differences between the intervention and control groups for hand function as measured by the scores of the Fugl-Meyer Motor Assessment scale for the upper extremity (three RCTs, $n=57$ patients), the Action Research Arm test (two RCTs, $n=48$ patients), and the Box and Block timed manipulation tests (three RCTs, $n=42$ patients). A sensitivity analysis, in which the results of one trial were removed, found a non significant difference between the groups, but significant statistical heterogeneity ($I^2=65\%$).

There were no significant differences between the groups for reaction time of wrist and finger extension muscles (three RCTs, $n=46$ patients) and the maintenance of sustained maximum isometric contractions of the wrist and finger extensor muscles for five seconds (two RCTs, $n=31$ patients).

Significant statistical heterogeneity was found across the RCTs for the results of the Fugl-Meyer tests. There was no statistically significant heterogeneity found across the included trials for the remaining outcomes.

**Authors’ conclusions**

There were no statistically significant differences in effects between usual care and electromyography-triggered neuromuscular electrical stimulation on wrist and finger extensor muscles on hand function in patients who had suffered a stroke. Most of the trials were of poor methodological quality and were characterised by small sample sizes, and insufficient contrast between intervention and control treatments.

**CRD commentary**

The review addressed a clear question and criteria for the inclusion of studies were clearly stipulated. The restriction to trials published in a particular language meant that there was risk of language bias. There were also no attempts to identify unpublished studies, so publication bias could not be ruled out. Steps were reported by the authors to minimise errors and bias in the assessment of methodological quality, but not for the processes of study selection and data extraction.

The authors correctly acknowledged limitations of both the review and the included trials; most of the trials were of poor methodological quality.

Shortcomings of the included trials, and the risks of language and publication bias, mean that it is difficult to draw conclusions about the reliability of the authors’ conclusions, and the results of the review should be interpreted with some caution.

**Implications of the review for practice and research**
Practice: The authors did not state any implications for practice.

Research: The authors stated that there is a need for a multi-centre study of electromyography-triggered neuromuscular electrical stimulation due to the limitations of the studies in the review, with careful selection of patients in terms of: time periods post-stroke; prognosis and hand function at baseline; and interventions with higher treatment intensities and larger contrasts between the intervention and control groups. They also recommended that the use of bilateral upper limb training with electromyography-triggered neuromuscular electrical stimulation above unilateral stimulation needs to be underpinned in a large randomised clinical trial. Further studies should also investigate treatment effects within the first five weeks post-stroke, as the functional outcome of the upper limb post-stroke is not fully defined.

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