Therapeutic electrical stimulation to improve motor control and functional abilities of the upper extremity after stroke: a systematic review

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Authors' objectives
To assess the available evidence on the effect of therapeutic electrical stimulation (TES) on motor control and functional abilities of the affected upper extremity after stroke. In addition, to assess the relationship between the reported effects and the patient characteristics, method of stimulation or methodological quality.

Searching
MEDLINE, EMBASE, CINAHL and the database of the Cochrane Field Rehabilitation and Related Therapies were searched up to December 2001, using the following keywords: 'electric stimulation', 'electric stimulation therapy', 'neuro-muscular stimulation', 'stroke', 'cerebrovascular disorders', 'hemiplegia', 'hemiparesis', 'arm', 'upper extremity' and 'rehabilitation'. The MEDLINE search strategy was detailed in an appendix to the paper. In addition, the references of relevant publications were checked. Publications in English, German, French or Dutch were selected.

Study selection
Study designs of evaluations included in the review
Randomised controlled trials (RCTs) were eligible for inclusion in the review.

Specific interventions included in the review
Stimulation with surface electrodes, defined as TES. This was applied as either neuromuscular electrical stimulation, EMG-triggered electrical stimulation, positional feedback stimulation training or transcutaneous electrical nerve stimulation; each applied by different devices. The control groups received sensory stimulation in one study, 'standard therapy' in two others and 'additional therapies' in the final three studies. 'Additional therapies' included: extra individual therapy consisting of range of motion and strengthening exercises of the impaired wrist; trials of voluntary wrist-lifting; and a visit from the intervention physiotherapist three times a week to discuss progress in rehabilitation. Studies which focused on invasive techniques, such as electro-acupuncture or implanted electrodes, were excluded.

Participants included in the review
Participants who had experienced stroke of any severity from acute, sub-acute or chronic stages after stroke, were eligible for inclusion in the review. The mean age of the participants ranged from 59.4 to 73 years.

Outcomes assessed in the review
Studies using outcome measures which assessed motor control and functional abilities were eligible for inclusion in the review. The authors identified up to 25 different outcomes assessed in the six included studies. All used at least two measures, but none distinguished between the primary and secondary outcome measures. All of the studies measured motor control, using active range of motion, isometric strength, grip strength, Fugl-Meyer Motor Assessment (upper extremity part), or the Motor Assessment Scale. Two studies assessed functional abilities using the Action Research Arm test, 9-hole peg test or box and block test.

How were decisions on the relevance of primary studies made?
The authors do not state how the papers were selected for the review, or how many of the reviewers performed the selection.

Assessment of study quality
The validity of the studies was assessed on the basis of 19 criteria relating to patient selection (4), intervention (5), outcome measures (7) and statistics (3). Two raters assessed the validity independently. In cases of disagreement, consensus was reached by discussion or, if necessary, by consulting a third party.
Data extraction
The authors state that the reviewers selected the outcome measures they considered most relevant for motor control and for functional ability in each study; no further information on the data extraction process was provided. For these primary outcome measures, the effect of electrical stimulation (as reported in the original study), was assessed as positive (in favour of the electrical stimulation group, p less than or equal to 0.05), negative (in favour of the control group, p less than or equal to 0.05) or no difference.

The following data were extracted: the number of patients, age (years), stage, time post stroke, severity, intervention, muscles targeted (intervention group), the duration of the intervention, and the outcome measures. The effect sizes were calculated by dividing the difference in gain between both treatment groups by the pooled standard deviation (see Other Publications of Related Interest). It was not possible to calculate the effect sizes for all primary outcome measures due to insufficient data.

Methods of synthesis
How were the studies combined?
The studies were combined narratively according to whether there was a positive or negative effect on motor control and functional abilities. A pooled analysis was not performed owing to the heterogeneity of the included studies.

How were differences between studies investigated?
The authors state that the studies selected were too heterogeneous to pool, although no formal test of heterogeneity was reported. In two studies, a post-hoc subgroup analysis was performed by dividing the more severely affected from those less severely affected.

Results of the review
Six RCTs (n=207) were included in the review.

Four of the six trials reported a positive effect on motor control, while one of the two studies assessing functional abilities reported a positive effect. The effect sizes ranged from 0.55 to 1.46. In the post-hoc subgroup analysis (two studies), one study revealed a significantly better effect on motor control in the less severely affected group than in the more severely affected; the other study reported a significant effect on functional abilities in the less severely affected group. Three studies performed follow-up measurements; the effect was still positive 4 weeks after the end of the treatment in one of these. No relationships were found between the reported effect and the stage after stroke, the method of TES or the contrast in intensity of therapy.

Authors' conclusions
The results suggest that electrical stimulation has a positive effect on motor control, although it is not known if this improvement is clinically relevant. No conclusions can be drawn concerning the effect of electrical stimulation on functional abilities.

CRD commentary
The review question and the study selection criteria were clear. The literature search seemed reasonably comprehensive, with publications in German, French, Dutch and English sought, but the start dates of the search were not specified. The authors provided details of the validity assessment, but did not state how the literature selection process took place, or give full details of the data extraction. The study details were presented clearly. The decision not to pool the data from the selected studies seemed appropriate given their heterogeneity.

The authors' conclusions seem appropriately cautious given the limitations of the data presented.

Implications of the review for practice and research
Practice: The authors deliver a 'clinical message' that TES appears to have a positive effect on motor control of the
upper extremity in stroke patients, although at present there is no evidence that any one method of TES is superior to another. However, there is as yet no evidence for a positive effect of TES on functional abilities.

Research: The authors state that further research is necessary to clarify the ambiguities concerning the optimal method of stimulation, and to identify the characteristics of patients who will benefit most from electrical stimulation. Explanatory trials are required to determine the efficacy and to elucidate the specific mechanism of action of electrical stimulation. Further research should also assess the effect of electrical stimulation on functional abilities, given that this is an important goal in the treatment of stroke patients.

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