The therapeutic effect of functional and transcutaneous electric stimulation on improving gait speed in stroke patients: a meta-analysis

CRD summary
The review assessed the therapeutic effect of functional and transcutaneous electric stimulation on the walking speed of stroke patients. The authors concluded that functional electric stimulation improved walking speed. There was insufficient information on transcutaneous electric stimulation. The analysis of the effect of functional electric stimulation was not sufficiently robust to support a strong conclusion.

Authors' objectives
To determine the therapeutic effect of lower-extremity functional electric stimulation (FES) and transcutaneous electric stimulation (TENS) on improving gait speed following a stroke.

Searching
MEDLINE, EMBASE and CINAHL were searched for articles published between 1966 and 2005; the search terms were reported. References listed in retrieved articles were used to identify additional studies. Only articles published in English were eligible.

Study selection
Study designs of evaluations included in the review
Prospective controlled trials and before-and-after studies were eligible for inclusion. Retrospective studies and case studies were excluded.

Specific interventions included in the review
Studies of FES and TENS with surface electrodes were eligible for inclusion. Studies using implanted or indwelling electrodes were excluded, as were studies of electric stimulation and treadmill training combined. One study was excluded because the participants were treated only once and the authors of the review believed this was unlikely to have a therapeutic effect. The included studies evaluated single-channel and multi-channel FES and single-channel TENS. The duration of treatment ranged from 3 to 12 weeks.

Participants included in the review
Studies in patients who had sustained a stroke were eligible for inclusion. Studies in mixed populations were excluded if the eligible population data were not reported separately. Most of the participants included were in the chronic stage of stroke recovery (onset of stroke >6 months); only one study was conducted in patients in the sub-acute stage (mean stroke onset 3.9 months). The source populations were not described in the included studies.

Outcomes assessed in the review
The outcome of interest was gait speed measured without electrical stimulation (therapeutic effect). Studies were excluded if data needed for the analysis were not available.

How were decisions on the relevance of primary studies made?
Consensus between two reviewers ensured that selected articles met the inclusion criteria.

Assessment of study quality
A published checklist was used to assess the methodological quality of the included studies and assign a composite score for the quality of reporting, internal validity, power and external validity (see Other Publications of Related Interest). Two reviewers applied the checklist independently and resolved any discrepancies through discussion. The highest possible score was 32.

Data extraction
Two reviewers independently extracted the data from the included studies. Data extracted from controlled trials included group means and standard deviations (SDs) and mean change in gait speed, SD, and the numbers of participants in the treatment and control groups. Data extracted from before-and-after studies included pre-treatment and post-treatment measures of gait speed and the average SD. Gait speed was extracted as metres/second (m/s) or time required to ambulate 10 m, or converted to m/s from metres/minute.

**Methods of synthesis**

**How were the studies combined?**

Estimates of the effectiveness of FES on gait speed from individual controlled studies were combined using a fixed-effect meta-analysis to calculate the pooled weighted mean difference (WMD) with 95% confidence intervals (CIs). A p-value of less than 0.01 was considered to be statistically significant.

The effect size (Cohen's d) on gait speed associated with FES and TENS was calculated for each of the controlled trials and before-and-after studies. The mean effect size was calculated within subgroups of studies to compare FES in acute and sub-acute (onset of stroke <6 months) stages of stroke recovery with FES in chronic (onset of stroke >6 months) stage of stroke recovery, single-channel FES with multi-channel FES, and FES with TENS. Effect sizes were considered large (d=0.8), medium (d=0.5) or small (d=0.2).

**How were differences between studies investigated?**

Heterogeneity between studies in the meta-analysis of WMDs was assessed using the chi-squared statistic (p<0.05 considered statistically significant). Differences in methods and treatment were described in the text.

**Results of the review**

Eight studies (161 participants) were included. Two of the studies were randomised controlled trials (RCTs; 56 participants), one was a controlled trial (19 participants), one a one-group crossover study (16 participants), one a two-group crossover study (20 participants) and three were before-and-after studies (50 participants).

The mean score for methodological quality was 15 out of 32. The mean score was 16 for the controlled trials and 14 for the before-and-after studies. For each study, the two independent raters were in initial agreement on at least 70% of the 27 items assessed.

The meta-analysis showed a statistically significant improvement in gait speed with FES compared with control (WMD 0.18 m/s, 95% CI: 0.08, 0.28, p<0.01), based on an RCT, a controlled trial and a two-group crossover study including 71 participants. Although statistical heterogeneity was not significant at the 0.05 level (p=0.09), the RCT showed no difference between the treatment and control groups while the controlled trial and two-group crossover study showed significant benefit in favour of FES.

The mean effect size in the two-group crossover study of FES in the acute or sub-acute stage of stroke recovery was larger (d=1.43) than the mean effect size of the four studies of FES in the chronic stage of recovery (d=0.40). The mean effect size of the two studies of multi-channel FES (d=1.38) was larger than the mean from the three studies that used single-channel FES (d=0.09). The mean effect size from the five studies of FES (d=0.61) was larger than the mean effect size from the three studies of TENS (d=0.30).

**Authors' conclusions**

FES is an effective intervention to improve gait speed following stroke. There are insufficient data to support a conclusion on the effectiveness of TENS.

**CRD commentary**

The review addressed a clear question and reported the inclusion and exclusion criteria, and the authors made an attempt to minimise selection bias. The search for studies was adequate but the restriction to English language articles could have introduced bias and overlooked relevant studies. Brief details of the characteristics of the included studies were presented. The data from each study used to calculate the effect size (d) were clearly presented. A thorough assessment of study quality was undertaken, but the findings were not used in the interpretation of the quantitative analyses.
The meta-analysis pooled results from randomised and non-randomised studies: similar composite scores for internal validity did not justify pooling data from different study designs without a detailed examination of the potential for bias and confounding in the individual studies. Heterogeneity in the meta-analysis was not investigated adequately despite the apparent clinical and methodological differences between studies. The pooled estimate of effect must, therefore, be interpreted with caution. In addition, the validity of comparing average effect sizes across studies with different design features in small subgroups is questionable.

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

**Practice:** The authors stated that FES can be an effective tool in rehabilitation following a stroke.

**Research:** The authors stated that more studies are needed to determine the effectiveness of TENS and FES, in particular single- or dual-channel FES devices and in people in the acute or sub-acute stage of recovery from stroke. RCTs with blinded outcome assessment and a period of follow-up are recommended.

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**Other publications of related interest**

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**Record Status**
This is a critical abstract of a systematic review that meets the criteria for inclusion on DARE. Each critical abstract contains a brief summary of the review methods, results and conclusions followed by a detailed critical assessment on the reliability of the review and the conclusions drawn.