ACRM
AMERICAN CONGRESS OF REHABILITATION MEDICINE

Archives of Physical Medicine and Rehabilitation

journal homepage: www.archives-pmr.org

Archives of Physical Medicine and Rehabilitation 2015;96:934-43

REVIEW ARTICLE (META-ANALYSIS)

# Functional Electrical Stimulation Improves Activity After Stroke: A Systematic Review With Meta-Analysis

Owen A. Howlett, MaOT,[a,b] Natasha A. Lannin, PhD,[a,c,d] Louise Ada, PhD,[e] Carol McKinstry, PhD[a]

*From the [a]Department of Occupational Therapy, La Trobe University, Bundoora, VIC; [b]Bendigo Health, Bendigo, VIC; [c]Occupational Therapy Department, Alfred Health, Prahran, VIC; [d]The John Walsh Centre of Rehabilitation Research, Sydney Medical School (Northern), University of Sydney, St Leonards, NSW; [e]Department of Physiotherapy, University of Sydney, Lidcombe, NSW; and La Trobe Rural Health School, La Trobe University, Bendigo, VIC, Australia.*

**Abstract**

**Objective:** To investigate the effect of functional electrical stimulation (FES) in improving activity and to investigate whether FES is more effective than training alone.

**Data Sources:** Cochrane Central Register of Controlled Trials, Ovid Medline, EBSCO Cumulative Index to Nursing and Allied Health Literature, Ovid EMBASE, Physiotherapy Evidence Database (PEDro), and Occupational Therapy Systematic Evaluation of Effectiveness.

**Study Selection:** Randomized and controlled trials up to June 22, 2014, were included following predetermined search and selection criteria.

**Data Extraction:** Data extraction occurred by 2 people independently using a predetermined data collection form. Methodologic quality was assessed by 2 reviewers using the PEDro methodologic rating scale. Meta-analysis was conducted separately for the 2 research objectives.

**Data Synthesis:** Eighteen trials (19 comparisons) were eligible for inclusion in the review. FES had a moderate effect on activity (standardized mean difference [SMD], .40; 95% confidence interval [CI], .09−.72) compared with no or placebo intervention. FES had a moderate effect on activity (SMD, .56; 95% CI, .29−.92) compared with training alone. When subgroup analyses were performed, FES had a large effect on upper-limb activity (SMD, 0.69; 95% CI, 0.33−1.05) and a small effect on walking speed (mean difference, .08m/s; 95% CI, .02−.15) compared with control groups.

**Conclusions:** FES appears to moderately improve activity compared with both no intervention and training alone. These findings suggest that FES should be used in stroke rehabilitation to improve the ability to perform activities.

Archives of Physical Medicine and Rehabilitation 2015;96:934-43



Stroke is the leading cause of disability in the Western world.[1,2] Such disability arises from limitations in activities (eg, walking) and reduced participation in daily life tasks (eg, self-care, managing household chores, property maintenance).[3] With hemiplegia contributing significantly to this inability to perform meaningful activities and participate fully in life after stroke,[4] improving motor outcomes after stroke is essential.

To improve outcomes after stroke, intervention focuses on improving not only the impairment level, but addressing activity limitations (eg, walking, moving objects) and participation restrictions.[5] Electrical stimulation is one such intervention that has the potential to improve motor outcomes and as such, potentially lead to increased activity performance and participation after stroke. However, there are various forms of electrical stimulation. Functional electrical stimulation (FES) stimulates muscles to contract during the performance of an activity (eg, sitting, standing up from a chair, walking, reaching for and manipulating objects), with the goal of improving the performance of that activity.[5] The perceived benefit of FES for survivors of stroke is that it can facilitate practice of activities that would not otherwise occur because of hemiparesis. In addition, FES can engage the stroke survivor's attention, be repetitive, be challenging, and can provide sensory and visual feedback to the participant. These are common

Presented to Occupational Therapy Australia, July 24−27, 2013, Adelaide, SA, Australia; and Occupational Therapy Australia, May 2−3, 2014, Melbourne, VIC, Australia.

Disclosures: none.

0003-9993/15/$36 - see front matter © 2015 by the American Congress of Rehabilitation Medicine
http://dx.doi.org/10.1016/j.apmr.2015.01.013

attributes labeled as essential components of an effective intervention to promote motor recovery after stroke.[6]

Three previous systematic reviews have investigated the effect of FES for increasing movement and activity after stroke, and all have investigated lower-limb function.[7-9] In 2006, Robbins et al[9] reported that FES resulted in .18m/s (95% confidence interval [CI], .08−.28) faster walking speed than walking training alone or no intervention, based on a meta-analysis of 3 controlled trials in chronic stroke. Then in 2009, Roche et al[8] concluded that evidence for a therapeutic effect of FES was inconclusive, based on the individual examination of 30 studies of peroneal nerve stimulators ranging from case studies to randomized trials. Finally, in 2012, Pereira et al[7] reported that FES resulted in .38 standardized mean difference (SMD) (95% CI, .08−.68) further walking distance than walking training alone or no intervention, based on 6 controlled trials in the chronic phase after stroke. Results of these prior systematic reviews demonstrate the previous focus in the research literature on the lower limb and conducting trials in the chronic population. In light of the limitations of these prior reviews, the clinical conclusion to date was that there was insufficient high-level evidence to support the routine use of FES for improving both upper- and lower-limb motor function.[10]

Therefore, the aim of this systematic review was to examine the latest evidence for the use of FES after stroke. The specific research questions were as follows: (1) Is FES effective in improving activity after stroke? (2) Is FES more effective than activity training alone?

To make recommendations based on the highest level of evidence, this review included only moderate-to high-quality randomized or controlled trials of adults with stroke using FES to contract muscles during the performance of activities, with the aim of improving activity performance. Review protocol is available online (http://www.crd.york.ac.uk/PROSPERO/display_record.asp?ID=CRD42012003054).

# Methods

## Identification and selection of trials

The following 6 electronic databases were searched on June 22, 2014: Cochrane Central Register of Controlled Trials (studies to June 22, 2014), Ovid Medline (studies from 1946 to June 22, 2014), EBSCO Cumulative Index to Nursing and Allied Health Literature (studies from 1981 to June 22, 2014), Ovid EMBASE (studies from 1947 to June 22, 2014), Physiotherapy Evidence Database (PEDro) (www.pedro.org.au) (studies to June 22, 2014), and Occupational Therapy Systematic Evaluation of Effectiveness (www.otseeker.com) (studies to June 22, 2014) for relevant articles without language restrictions using words related to stroke and randomized, quasi-randomized, or controlled trials and words related to functional electrical stimulation (contact corresponding author for full search strategy). One author (O.H.) screened all trials based on the title and abstract. Full-text articles for potentially relevant trials were retrieved and their reference lists screened. Two authors (O.H. and N.A.L.) independently reviewed full-text articles for eligibility using the inclusion criteria outlined in figure 1. Where inclusion could not be established based on the information provided in the publication, the author of the trial was contacted to ascertain missing information. All disagreements regarding inclusion into the review were resolved through discussion between 2 reviewers and if required a third reviewer. Articles reporting the same research data were linked together to ensure data from each trial were only included once in the analysis.

***List of abbreviations:***

| | |
|---|---|
| **CI** | **confidence interval** |
| **FES** | **functional electrical stimulation** |
| **PEDro** | **Physiotherapy Evidence Database** |
| **SMD** | **standardized mean difference** |

Design
- Randomised or controled clinical trial
- Methodological quality of PEDro >4

Participants
- Adults: 18 +
- 80% of participants to had a stroke, remaining 20% of participants to have a stroke like condition.

Intervention
- Electrical stimulation via surface electrodes that produces a muscle contraction causing movement of a limb during practice of an activity
- FES the primary intervention, i.e., practice of activity for the majority of the intervention, e.g., walking or grasp/release of objects

Outcome measures
- Measures of activity limitation without electrical stimulation.

Comparisons
- FES versus nothing/ placebo
- FES versus same activity training

**Fig 1** Inclusion criteria.

## Assessment of characteristics of trials

### Quality

The quality of the included trials into the systematic review was assessed by the PEDro scale and Jadad scale. One reviewer determined the risk of bias for each study using PEDro scores[11] obtained from the PEDro.[12] If a score was not available from the database, it was calculated by 2 review authors independently (O.H. and N.A.L.) who had undergone the PEDro training program. Only trials of moderate (ratings of 5 or 6) and high (ratings of 7 or 8) quality[13] were included in the review. One reviewer (O.H.) established a Jadad score[14] for each included trial.

### Participants

Trials involving adult participants with stroke of any level of disability and any chronicity were included. The number of participants, their mean age, their sex distribution, and their time since the onset of stroke were recorded to assess the similarity of the trials.

### Intervention

The experimental intervention was FES (ie, electrical stimulation producing muscle contraction delivered via surface electrodes during practice of an upper- or lower-limb activity). The control group intervention was categorized as either no intervention or placebo or as same activity training, defined as the training of the same activity as the experimental group but without any electrical stimulation. Muscle(s) stimulated, activity trained, and duration and frequency of the intervention were recorded to assess the similarity of the trials.

### Outcome measures

Only measures that reflected the International Classification of Function domain of activity performance were used in analyses because there were insufficient participation measures reported in the trials. In the trials where only 1 measure of activity was available, this measure was chosen. Where >1 measure of activity was available for a single trial, reviewers chose the outcome measure that closest reflected the task being trained