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Research

Biofeedback improves performance in lower limb activities more than usual therapy in people following stroke: a systematic review

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KEY WORDS

Stroke
Physical therapy
Biofeedback
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CrossMark

ABSTRACT

Question: Is biofeedback during the practice of lower limb activities after stroke more effective than usual therapy in improving those activities, and are any benefits maintained beyond the intervention? **Design:** Systematic review with meta-analysis of randomised trials with a PEDro score > 4. **Participants:** People who have had a stroke. **Intervention:** Biofeedback (any type delivered by any signal or sense) delivered concurrently during practice of sitting, standing up, standing or walking compared with the same amount of practice without biofeedback. **Outcome measures:** Measures of activity congruent with the activity trained. **Results:** Eighteen trials including 429 participants met the inclusion criteria. The quality of the included trials was moderately high, with a mean PEDro score of 6.2 out of 10. The pooled effect size was calculated as a standardised mean difference (SMD) because different outcome measures were used. Biofeedback improved performance of activities more than usual therapy (SMD 0.50, 95% CI 0.30 to 0.70). **Conclusion:** Biofeedback is more effective than usual therapy in improving performance of activities. Further research is required to determine the long-term effect on learning. Given that many biofeedback machines are relatively inexpensive, biofeedback could be utilised widely in clinical practice. **[Stanton R, Ada L, Dean CM, Preston E (2016) Biofeedback improves performance in lower limb activities more than usual therapy in people following stroke: a systematic review. *Journal of Physiotherapy* 63: 11–16]**

Introduction

This is an update of a systematic review[1] that examined the effect of biofeedback in training lower limb activities after stroke. Biofeedback is equipment that transforms biological signals into an output that can be understood by the learner, providing information to the learner that is not consciously available. That is, biofeedback takes intrinsic physiological signals and makes them extrinsic, giving the person immediate and accurate feedback of information about these body functions. Biofeedback can be delivered through various senses, such as visual, auditory and tactile systems, and can provide information about the kinematics, kinetics and/or electromyography of activities. Biofeedback is available from medical equipment (eg, electromyography, force platforms and positional devices traditionally used in clinical practice); or from non-medical equipment that is increasingly available and used in stroke rehabilitation (eg, recreational games such as the Nintendo® Wii™). Biofeedback can be used in addition to verbal content; however, it also has the advantage that it can be set up for the patient to use when left to practise alone. However, biofeedback is not commonly used in stroke rehabilitation.[2]

The previous version of this review,[2] which was published in 2011, examined biofeedback broadly in training lower limb activities after stroke, including trials where any form of biofeedback was provided during practice of the whole activity (rather than part of the activity), with outcomes measured during the same activity. Twenty-two trials met the inclusion criteria and were included in the review; however, meta-analyses demonstrated significant heterogeneity that was best explained by the quality of the included trials. When analyses were limited to higher quality trials (PEDro score > 4), biofeedback had a moderate effect in the short term (10 trials, 241 participants, SMD 0.49, 95% CI 0.22 to 0.75) compared with usual therapy, which was maintained beyond intervention (five trials, 138 participants, SMD 0.41, 95% CI 0.06 to 0.75), suggesting that learning had occurred. For a direct comparison of the effect of biofeedback interventions and usual therapy (which includes therapist communication), a post hoc meta-analysis was conducted of those trials where the amount of practice was equal in each group. That is, trials where the control group practised the same activity for the same amount of time as the experimental group, with the only difference being the substitution of biofeedback for therapist communication (presumably including feedback) in the experimental group. This meta-analysis demonstrated a moderate effect of a similar magnitude to the overall analysis (eight trials, 170 participants, SMD 0.51, 95% CI 0.20 to 0.83), suggesting that biofeedback is superior to therapist communication.

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Since that review[1] was published in 2011, a number of additional trials have been published that investigated the effect of biofeedback, warranting an update of the review. In particular, the potential of using recreational games in stroke rehabilitation has gained attention. The inclusion criteria for this updated review incorporated findings from the previous review. Specifically, this meant that the updated review would include any randomised trial investigating biofeedback from any signal (position, force, EMG) via any sense (visual, auditory, tactile), delivered concurrently during whole activity practice, compared with usual therapy that was practice of the same activity for the same amount of time in the control group with no biofeedback (but presumably with therapist communication), with outcome measures at the activity level and congruent with the activity trained. This ensures a true comparison of the effect of biofeedback compared with usual therapist communication. For the biofeedback intervention, inclusion in this update was based on whether the biofeedback delivered was concurrent rather than terminal feedback. This meant that commercially available recreational games would be included if the majority of the games played within the study delivered concurrent biofeedback, rather than inclusion based on the equipment itself. In order to make recommendations based on the highest level of evidence, this review included only randomised trials with a PEDro score > 4.

Therefore, the research questions for this systematic review were:

1. In adults following stroke, is biofeedback during the practice of lower limb activities more effective than usual therapy in improving those activities in the short term?
2. Are any benefits maintained beyond the intervention?

Box 1. Inclusion criteria.

Design
- High-quality randomised trial or quasi-randomised trial (PEDro score > 4/10)

Participants
- Adults
- Diagnosis of cerebrovascular stroke
- Any level of disability and any time after stroke

Intervention
- Experimental intervention includes biofeedback using any signal (EMG, force, position) via any sensory system (visual, auditory, tactile)
- Part of intervention must be biofeedback during practice of the whole activity
- Practice of whole activity must involve movement (such as reaching in sitting or weight shift in standing)
- Groups must practice the same activity for the same amount of time as the control practice (ie, only difference is feedback delivered)

Outcome measures
- Measures of lower limb activity (sitting, standing up, standing or walking)
- Measures congruent with the activity trained
- Measures of activity must involve movement

Comparisons
- Biofeedback versus usual therapy during the same activity

Method

Identification and selection of trials

Searches were conducted of: MEDLINE (1950 to September 2015); CINAHL (1981 to September 2015); EMBASE (1980 to September 2015); PEDro (to September 2015); the COCHRANE Library (to September 2015) and the PubMed databases (to September 2015) for relevant articles without language restrictions, using words related to *stroke* and *randomised*, *quasi-randomised* or *controlled trials* and words related to *biofeedback* (such as biofeedback, electromyography, joint position, and force) during *lower limb activities* (such as sitting, sit to stand, standing and walking) (see Appendix 1 on the eAddenda for the full search strategy). Titles and abstracts (where available) were displayed and screened by one reviewer to identify relevant trials. Full paper copies of relevant trials were retrieved and their reference lists were screened. The methods of the retrieved papers were extracted and reviewed independently by two reviewers (RS and EP) using predetermined criteria (Box 1). Disagreement or ambiguous issues were resolved by consensus after discussion with a third reviewer (LA).

Assessment of characteristics of trials

Quality

The quality of included trials was assessed by extracting PEDro scores from the Physiotherapy Evidence Database (www.pedro.org.au). Two trained raters independently carried out rating of trials in this database, and disagreements were resolved by a third rater. Where a trial was not included in the database, it was independently assessed by two authors who had completed the PEDro Scale training tutorial on the Physiotherapy Evidence Database. Only trials with a PEDro rating > 4 were eligible for inclusion in the review.

Participants

Trials involving adult participants of either gender, at any level of initial disability, at any time following stroke were included. Age, gender, and time since stroke were recorded to describe the participants in each trial.

Intervention

The experimental intervention could be of any type of biofeedback, that is, using any signal (position, force, EMG) via any sense (visual, auditory, tactile). At least some of the intervention had to involve practice of the whole activity, and practice of the activity had to involve movement (such as reaching in sitting or weight shift in standing). The control intervention must have been the same activity, practised for the same amount of time, where the only difference between the groups was that the intervention group received biofeedback in addition to usual therapy (ie, therapist communication). Type of biofeedback, activity trained, and duration and frequency of the intervention were recorded to describe the trials.

Outcome measures

Measures of lower limb activity that were congruent with the activity in which biofeedback was applied were used in the analysis. Where multiple measures for one activity were reported, a measure was chosen that best reflected the aim of the biofeedback intervention (eg, step length). The measures used to record outcomes and the timing of measurement were recorded and compared to describe the trials.

Data analysis

Data were extracted from the included trials by one reviewer and crosschecked by a second reviewer. Information about the method (ie, design, participants, lower limb activity trained, intervention, measures) and data (ie, number of participants and mean (SD) of outcomes) were extracted. Post-intervention scores were used to obtain the pooled estimate of the effect of intervention in the short term (immediately following intervention) and in the longer term (some time beyond the intervention), as these were reported in a majority of studies. Since different outcome measures were used, the effect size was reported as