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Research

Walking training with cueing of cadence improves walking speed and stride length after stroke more than walking training alone: a systematic review

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KEYWORDS

Stroke
Cue
Gait
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ABSTRACT

Question: After stroke, is walking training with cueing of cadence superior to walking training alone in improving walking speed, stride length, cadence and symmetry? **Design:** Systematic review with meta-analysis of randomised or controlled trials. **Participants:** Adults who have had a stroke. **Intervention:** Walking training with cueing of cadence. **Outcome measures:** Four walking outcomes were of interest: walking speed, stride length, cadence and symmetry. **Results:** This review included seven trials involving 211 participants. Because one trial caused substantial statistical heterogeneity, meta-analyses were conducted with and without this trial. Walking training with cueing of cadence improved walking speed by 0.23 m/s (95% CI 0.18 to 0.27, I^2 = 0%), stride length by 0.21 m (95% CI 0.14 to 0.28, I^2 = 18%), cadence by 19 steps/minute (95% CI 14 to 23, I^2 = 40%), and symmetry by 15% (95% CI 3 to 26, random effects) more than walking training alone. **Conclusions:** This review provides evidence that walking training with cueing of cadence improves walking speed and stride length more than walking training alone. It may also produce benefits in terms of cadence and symmetry of walking. The evidence appears strong enough to recommend the addition of 30 minutes of cueing of cadence to walking training, four times a week for 4 weeks, in order to improve walking in moderately disabled individuals with stroke. **Review Registration:** PROSPERO (CRD42013005873). **[Nascimento LR, de Oliveira CQ, Ada L, Michaelsen SM, Teixeira-Salmela LF (2015) Walking training with cueing of cadence improves walking speed and stride length after stroke more than walking training alone: a systematic review. *Journal of Physiotherapy* 61: 10–15]**

Introduction

Recent data indicates that over 30 million people in the world have experienced and survived stroke.[1] Despite recent advances in medical and rehabilitation sciences, many individuals have residual walking disability after stroke, which has long-lasting implications for quality of life and ability to participate in activities of daily living.[2,3] If walking performance is poor after stroke, community activity may be limited and people may become housebound and isolated from society.[4,5] One of the main aims of rehabilitation is to enhance community ambulation skills.

After stroke, individuals typically demonstrate reduced walking speed, decreased stride length and cadence, as well as temporal asymmetry. A systematic review[6] of ambulatory people after stroke reported mean walking speeds ranging from 0.4 to 0.8 m/s, compared with 1.0 to 1.2 m/s in healthy, older adults.[7] Previous studies[8,9] have also reported mean stride lengths ranging from 0.50 to 0.64 m in people after stroke, compared with 1.1 to 1.4 m in healthy, older adults, and mean cadence of 50 to 63 steps/minute, compared with 102 to 114 steps/minute in healthy, older adults.[7] Temporal symmetry of the affected leg to the non-affected leg is reported as ranging from 0.40 to 0.64, where 1.00 is symmetrical.[8,9] In summary, walking parameters in ambulatory people after stroke are approximately half of the values expected in older, able-bodied adults.

One approach that has the potential to improve multiple parameters of walking after stroke is cueing of cadence delivered via an external auditory cue during walking. Using a metronome or specifically prepared music tapes, the patient's steps are matched to the beat of the metronome or music in order to synchronise motor responses into stable time relationships.[8,9] The patient is asked to take steps according to the beat, so the rhythmic beat acts as a cue. If the beats are of a consistent frequency, this cueing will promote the temporal symmetry of walking. If the frequency of these consistent beats is increased, cadence and, therefore, speed will also increase. Whether stride length is also increased is an unanswered question. Therefore, cueing of cadence is an inexpensive adjunct to walking training, whether overground or on a treadmill, that has the potential to improve walking after stroke.

Three previous reviews have examined cueing of cadence but these have not used meta-analysis.[10–12] All three reviews included studies of all neurological conditions, but reported the studies relating to stroke separately. Thaut and Abiru[10] concluded that rhythmic auditory stimulation has a strong facilitating effect on

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walking, based on three trials.[8,9,13] Bradt et al[11] concluded that it may increase walking parameters such as step length, cadence and symmetry, based on two trials.[8,9] More recently, Wittner et al[12] concluded that there is moderate evidence that rhythmic auditory cueing improves walking speed and step length, but insufficient evidence of its effect on cadence and symmetry, based on three trials.[8,9,14] Two systematic reviews have examined the effect of exercise after stroke, which reported results on rhythmic auditory cueing separately. van Peppen et al[15] reported a standardised mean difference (SMD) of 0.91 (95% CI 0.40 to 1.42) on walking speed and 0.68 (95% CI 0.06 to 1.30) on step length, based on three trials,[8,13,16] whereas more recently, Veerbeek et al[17] reported a non-significant SMD of 0.6 (95% CI −1.8 to 3.0) on walking speed and 0.15 (95% CI −1.4 to 1.7) on stride length, based on two trials of early rehabilitation.[9,18] Given that different trials have been examined in different reviews, a meta-analysis of the current evidence for this promising intervention is warranted.

The aim of this systematic review was to examine the efficacy of the addition of cueing of cadence to walking training for improving walking after stroke. The specific research question was:

After stroke, is walking training with cueing of cadence superior to walking training alone in improving walking speed, stride length, cadence and symmetry?

In order to make recommendations based on a high level of evidence, this review included only randomised or controlled trials.

Method

Identification and selection of trials

Searches were conducted of Medline (1946 to August 2013), CINAHL (1986 to August 2013), EMBASE (1980 to August 2013) and PEDro (to August 2013) for relevant studies without date or language restrictions. The search strategy was registered at PubMed/Medline and the authors received notifications about potential papers related to this systematic review. Search terms included words related to *stroke*, words related to *randomised*, *quasi-randomised* or *controlled trials*, and words related to *cueing of cadence* (such as auditory cueing, rhythmic cueing, acoustic cueing and external cueing) (see Appendix 1 on the eAddenda for the full search strategy). In order to identify relevant studies, the titles and abstracts of the retrieved records were displayed and screened by two reviewers (LRN and CQO). Full paper copies of peer-reviewed relevant papers were retrieved and their reference lists were screened to identify further relevant studies. The method section of the retrieved papers was extracted and reviewed independently by two reviewers (LRN and CQO) using predetermined criteria (Box 1). Both reviewers were blinded to authors, journal and results. Disagreement or ambiguities were resolved by discussion with a third reviewer (LA).

Box 1. Inclusion criteria.

Design
- Randomised or controlled trials

Participants
- Adults (>18 years)
- Diagnosis of stroke
- Ambulatory (walking speed of at least 0.2 m/s at baseline or participants able to walk without help, with or without walking aids)

Intervention
- Experimental intervention is any method of walking training with cueing of cadence

Outcome measures
- Measures of walking (speed, stride length, cadence, symmetry)

Comparisons
- Walking training with cueing of cadence vs walking training alone

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). The PEDro scale is an 11-item scale designed for rating the methodological quality (internal validity and statistical information) of randomised trials. Each item, except for Item 1, contributes one point to the total score (range 0 to 10 points). Where a trial was not included on the database, it was scored by a reviewer who had completed the PEDro Scale training tutorial.

Participants

Ambulatory adults at any time following stroke were included. Ambulatory was defined as having a walking speed of at least 0.2 m/s at baseline or when the participants were able to walk without help, with or without walking aids. Studies were included when at least 80% of the sample comprised ambulatory participants. To assess the similarity of the studies, the number of participants and their age, time since stroke and baseline walking speed were recorded.

Intervention

The experimental intervention was any method of walking training accompanied by cueing of cadence delivered to individuals after stroke. The control intervention could be any walking training without cueing of cadence. To assess the similarity of the studies, the session duration, session frequency and program duration were recorded.

Measures

Four walking outcomes were of interest: speed, stride length, cadence and symmetry. To assess the appropriateness of combining studies in a meta-analysis, the timing of the measurements of outcomes and the procedure used to measure the different walking outcomes were recorded.

Data analysis

Information about the method (ie, design, participants, intervention and measures) and results (ie, number of participants and means (SD) of walking outcomes) were extracted by two reviewers and checked by a third reviewer. Where information was not available in the published trials, details were requested from the corresponding author.

The post-intervention scores were used to obtain the pooled estimate of the effect of intervention, using the fixed effects model. In the case of significant statistical heterogeneity ($I^2 > 50\%$), a random effects model was applied. Post-hoc sensitivity analysis was performed if the result of the random effects model was different from that of the fixed effect model. The analyses were performed using The MIX–Meta–Analysis Made Easy program Version 1.7.[19,20] Where insufficient data were available for a study result to be included in the pooled analysis, the between-group difference was reported. For all outcome measures, the critical value for statistical significance was set at a level of 0.05 (two-tailed). The pooled data for each outcome were reported as weighted mean differences (MD) with a 95% CI.

Results

Flow of trials through the review

The electronic search strategy identified 3830 papers, but 23 were duplicates. After screening titles, abstracts and reference lists, 32 potentially relevant full papers were retrieved. Twenty-five papers failed to meet the inclusion criteria (see Appendix 2 on