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Research

Progressive resistance training increases strength after stroke but this may not carry over to activity: a systematic review

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KEY WORDS

Stroke
Strength
Progressive resistance training
Systematic review
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ABSTRACT

Question: Does progressive resistance training improve strength and activity after stroke? Does any increase in strength carry over to activity? **Design**: Systematic review of randomised trials with meta-analysis. **Participants**: Adults who have had a stroke. **Intervention**: Progressive resistance training compared with no intervention or placebo. **Outcome measures**: The primary outcome was change in strength. This measurement had to be of maximum voluntary force production and performed in muscles congruent with the muscles trained in the intervention. The secondary outcome was change in activity. This measurement had to be a direct measure of performance that produced continuous or ordinal data, or with scales that produced ordinal data. **Results**: Eleven studies involving 370 participants were included in this systematic review. The overall effect of progressive resistance training on strength was examined by pooling change scores from six studies with a mean PEDro score of 5.8, representing medium quality. The effect size of progressive resistance training on strength was 0.98 (95% CI 0.67 to 1.29, I^2 = 0%). The overall effect of progressive resistance training on activity was examined by pooling change scores from the same six studies. The effect size of progressive resistance training on activity was 0.42 (95% CI –0.08 to 0.91, I^2 = 54%). **Conclusion**: After stroke, progressive resistance training has a large effect on strength compared with no intervention or placebo. There is uncertainty about whether these large increases in strength carry over to improvements in activity. **Review registration**: PROSPERO CRD42015025401. **[Dorsch S, Ada L, Alloggia D (2018) Progressive resistance training increases strength after stroke but this may not carry over to activity: a systematic review. *Journal of Physiotherapy* XX: XX–XX]**

Introduction

Stroke is the leading cause of adult disability in the western world.[1] Using the International Classification of Functioning, Disability and Health framework,[2] loss of strength after stroke (ie, the loss of the ability to produce normal amounts of muscle force) is the main impairment contributing to activity limitations,[3–5] and also to participation restrictions.[6,7] The loss of strength after stroke is extensive. Five studies that have compared the strength of the affected leg of stroke survivors early after stroke to that of age-matched controls found that the strength of the affected leg is around 50% of the strength of the control participants.[8–12] One study found similar levels of loss of strength in the affected leg of stroke survivors late after stroke.[13] In view of the extent of loss of strength and the significant associations of this impairment with activity limitations after stroke, it is essential to know whether interventions with the potential to increase strength after stroke are effective.

Progressive resistance training is a well-established form of exercise for increasing muscle strength. The principles of progressive resistance training are that muscles are exercised against the maximum amount of external resistance they can sustain (in isometric training) or move (in dynamic training) for a small number of repetitions, in order to overload the muscle. Additionally, the exercise is systematically progressed, for example, by increasing the amount of resistance.[14] The muscles then continue to be overloaded and this provides the stimulus for neural and muscular changes that result in increased strength. There is Level 1 evidence that progressive resistance training increases strength in normal populations, novice-to-intermediate exercisers, and older people.[14]

Three systematic reviews[15–17] have meta-analysed randomised trials that examine the effect of progressive resistance training on strength and activity after stroke. One of these reviews investigated the upper limb muscles[15] and one investigated the lower limb muscles;[17] each found moderate to large effects of progressive resistance training on strength, but either little or no carryover of this increase in strength to activity. The third review[16] found no effect on either strength or activity. However, all three reviews included trials that used strength training of low intensity, so we do not know the effect of true progressive resistance training, as defined by the American College of Sports Medicine,[14] on strength

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after stroke. The low intensity may be the reason behind the lack of carryover of increases in strength to activity. True progressive resistance training may produce larger changes in strength, and these may be large enough to carry over to activity. This warrants a review containing only trials that comply with the American College of Sports Medicine criteria for progressive resistance training (ie, using a load of 8 to 12 repetitions maximum (RM) for at least two sets with progressive increases of the load).

Therefore, the research questions for this systematic review were:

1. What is the effect of progressive resistance training on strength after stroke?
2. Does any increase in strength carry over to activity?

Method

Identification and selection of studies

Searches were conducted of EMBASE, the Cochrane Central Register of Controlled Trials (CENTRAL), and the Physiotherapy Evidence Database (PEDro) from inception to August 2016 for relevant studies with no date or language restrictions. Search terms included: words related to stroke; words related to randomised and quasi-randomised, controlled trials; and words related to progressive resistance training, such as muscle strengthening, progressive resistance and weight lifting (see Appendix 1 on the eAddenda). Hand searching of the identified studies' reference lists was undertaken. Title and abstracts were screened independently by two reviewers (SD and DA) to identify relevant studies. Full text copies of relevant papers were retrieved and reviewed independently by two reviewers (SD and DA) against predetermined eligibility (Box 1) criteria. If the two reviewers disagreed about the eligibility of a study, a discussion was held with the third reviewer (LA) until a consensus was reached. The search was conducted again in May 2017 and no new eligible studies were identified.

Assessment of characteristics of the studies

Quality

The quality of included trials was assessed using the PEDro scale, which 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 PEDro score (out of 10 points). Scores were extracted for the trials that had been rated on the PEDro website. If a study was not rated on PEDro, it was rated by a reviewer who had completed the PEDro scale training program.

Participants

Trials involving adult participants of either gender at any time following stroke were included. The number of participants, age, time since stroke and initial strength of the affected leg or arm were recorded to describe the trials.

Intervention

Trials were included if the experimental intervention was progressive resistance training, defined as exercising against a load that corresponds to 8 to 12 RM at least 2 days/week and the load progressed as strength increases.[14] Trials were included where the control intervention was no intervention or a placebo. A placebo was defined as any intervention that did not involve an effortful muscle contraction and, hence, was unlikely to induce a strengthening effect (eg, muscle stretching).

Outcome measures

The primary outcome was strength of the affected arm or leg measured as maximum force or torque, immediately after the intervention and in muscles congruent with the muscles trained. Where multiple measures of strength were reported, the measure that best reflected the type of training (ie, isometric or dynamic) was used. For example, if the training was isokinetic progressive resistance training and the strength measures included isometric and isokinetic measures of strength, the isokinetic measure was used.

The secondary outcome was activity, measured by direct observation of performance (eg, 10-m walk test, and Block Test). Where multiple measures of activity were reported, the measure that best reflected the type of training was used. For example, if the progressive resistance training targeted the leg muscles, then a lower limb activity, such as walking, was used.

Data analysis

Information about the method (ie, design, participants, intervention, measures) and results (ie, number of data points, mean and SD of strength and activity) were extracted independently by two reviewers (SD and DA) and checked by a third reviewer (LA). If information was not available in the published papers, details were requested from the corresponding author. Since more trials reported change scores than pre-intervention and post-intervention scores, change scores were used for the pooled analysis of the effect of progressive resistance training on strength and activity immediately after the intervention. The outcomes of the analyses were reported as a standardised mean difference (SMD) and a 95% confidence interval (95% CI) because different outcome measures were used for both strength and activity. A random effects model was used. The analyses were performed using RevMan 5.3 software[a]. If data were unavailable to be included in the pooled analysis, the between-group results were reported. For all outcome measures, the critical value for statistical significance was set at a level of 0.05 (two-tailed).

Results

Flow of trials through the review

The electronic search strategy identified 1247 papers (excluding duplicates). After screening of the titles, abstracts and reference lists, 65 potentially relevant full papers were retrieved. After screening of the full papers, 53 papers failed to meet the inclusion criteria, and two papers reported on the same data set; therefore, 11 studies[18–29] were included in this systematic review. Figure 1 outlines the flow of papers through the review. See Appendix 2 on the eAddenda for a summary of the excluded papers.

Box 1. Inclusion criteria.

Design
- Randomised or quasi-randomised trial

Participants
- Adults (> 18 years old)
- Diagnosis of stroke
- Muscle strength enough for progressive resistance training or those participants reported separately

Intervention
- Progressive resistance training, defined as exercising against an external load that corresponds to 8 to 12 RM, at least twice per week, with resistance increased as strength increases

Outcome measures
- Muscle strength measured as maximum force/torque and congruent with the muscles trained, measured immediately after the intervention

Comparisons
- Progressive resistance training versus no intervention or placebo

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