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Research

Respiratory muscle training increases respiratory muscle strength and reduces respiratory complications after stroke: a systematic review

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KEY WORDS

Stroke
Systematic review
Respiratory muscle training
Strength
Physical therapy

CrossMark

ABSTRACT

Question: After stroke, does respiratory muscle training increase respiratory muscle strength and/or endurance? Are any benefits carried over to activity and/or participation? Does it reduce respiratory complications? **Design:** Systematic review of randomised or quasi-randomised trials. **Participants:** Adults with respiratory muscle weakness following stroke. **Intervention:** Respiratory muscle training aimed at increasing inspiratory and/or expiratory muscle strength. **Outcome measures:** Five outcomes were of interest: respiratory muscle strength, respiratory muscle endurance, activity, participation and respiratory complications. **Results:** Five trials involving 263 participants were included. The mean PEDro score was 6.4 (range 3 to 8), showing moderate methodological quality. Random-effects meta-analyses showed that respiratory muscle training increased maximal inspiratory pressure by 7 cmH_2O (95% CI 1 to 14) and maximal expiratory pressure by 13 cmH_2O (95% CI 1 to 25); it also decreased the risk of respiratory complications (RR 0.38, 95% CI 0.15 to 0.96) compared with no/sham respiratory intervention. Whether these effects carry over to activity and participation remains uncertain. **Conclusion:** This systematic review provided evidence that respiratory muscle training is effective after stroke. Meta-analyses based on five trials indicated that 30 minutes of respiratory muscle training, five times per week, for 5 weeks can be expected to increase respiratory muscle strength in very weak individuals after stroke. In addition, respiratory muscle training is expected to reduce the risk of respiratory complications after stroke. Further studies are warranted to investigate whether the benefits are carried over to activity and participation. **Registration**: PROSPERO (CRD42015020683). **[Menezes KKP, Nascimento LR, Ada L, Polese JC, Avelino PR, Teixeira-Salmela LF (2016) Respiratory muscle training increases respiratory muscle strength and reduces respiratory complications after stroke: a systematic review. *Journal of Physiotherapy* 62: 138–144]**

Introduction

Stroke is the second leading global cause of death and the leading cause of disability.[1] After stroke, the loss of ability to generate normal amounts of force is a major contributor to activity limitations and participation restrictions.[2–4] Previous studies have demonstrated that weakness after stroke affects not only the muscles of the upper and lower limbs, but also those of the respiratory system.[5,6] Patients typically demonstrate reduced maximal voluntary strength and decreased endurance of the inspiratory and expiratory muscles, as well as altered chest wall kinematics.[7–9] Studies have reported mean values of maximal inspiratory pressure ranging from 17 to 57 cmH_2O in people after stroke, compared with approximately 100 cmH_2O in healthy adults, and mean values of maximal expiratory pressure ranging from 25 to 68 cmH_2O, compared with approximately 120 cmH_2O in healthy adults.[7,9,10] That is, respiratory muscle strength in people after stroke is less than half of that expected in healthy adults. In addition, decreased respiratory function is associated with deconditioning, activity limitations, and respiratory complications,[11] which are a leading cause of non-vascular death after stroke.[12] Thus, implementing interventions with the potential to prevent morbidity and mortality in people with stroke is vindicated.[13]

One approach that has the potential to increase respiratory muscle strength and reduce respiratory complications after stroke is respiratory muscle training. In this type of training, patients are asked to perform repetitive breathing exercises against an external load, using a flow-dependent resistance or a pressure threshold.[14,15] Respiratory muscle training is based on the premise that respiratory muscles respond to training stimuli by undergoing adaptations to their structure in the same manner as any other skeletal muscles, when their fibres are overloaded. Respiratory muscles can be overloaded by requiring them to work for longer, at higher intensities, and/or more frequently than their typical workload.[16,17] Also, because respiratory muscle training not only imposes a resistance to the respiratory muscles, but also consists of hyperventilating for prolonged periods of time, it may have an additional effect on respiratory muscle endurance,[16,17] which could translate into a more efficient use of the respiratory muscles in activities of daily living.

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Two systematic reviews have examined the effect of inspiratory muscle strength training regimens on respiratory muscle strength after stroke, based on randomised, controlled trials. A Cochrane review[15] included two randomised trials (representing three comparisons), but did not perform a meta-analysis. When inspiratory muscle training was compared with no intervention, the effect on maximal inspiratory pressure was 3 cmH_2O (95% CI –2 to 9); when compared with sham intervention, the effect was 46 cmH_2O (95% CI 28 to 63); and when compared with other types of respiratory training, the effect was 0 cmH_2O (95% CI –6 to 6). When these results of strength training were entered into a meta-analysis in a recent review,[5] the pooled effect on maximal inspiratory pressure was 7 cmH_2O (95% CI 2 to 12), but with substantial statistical heterogeneity (I^2 = 95%).

An updated review of the current evidence is warranted because these reviews[5,15] included only two trials and did not examine the effects on respiratory endurance, the carryover effects to activity or participation, nor the incidence of respiratory complications.

Therefore, the research questions for this systematic review were:

1. Does respiratory muscle training (inspiratory and/or expiratory) increase respiratory muscle strength and/or endurance after stroke?
2. Are the benefits carried over to activity and/or participation?
3. Does respiratory muscle training reduce the occurrence of respiratory complications?

In order to make recommendations based on the highest level of evidence, this review included only randomised or quasi-randomised trials.

Method

Identification and selection of trials

Searches were conducted in the CINAHL (1986 to April 2015), EMBASE (1980 to April 2015), LILACS (1986 to April 2015), MEDLINE (1946 to April 2015) and PEDro (to April 2015) databases for relevant studies, without date or language restrictions. The search strategy was registered at PubMed/Medline and the authors received notifications regarding potential papers related to this systematic review. Search terms included words related to *stroke*, to *randomised* or *quasi-randomised trials*, and to *respiratory muscle training* (such as *inspiratory muscle training*, *expiratory muscle training*, *breathing exercises* and *respiratory therapy*). See Appendix 1 on the eAddenda for the full search strategy. Title and abstracts were displayed and screened by two reviewers (KKPM and PRA) to identify relevant studies. Full-text 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 independently reviewed by two researchers (LRN and JCP) using pre-determined criteria (Box 1). Both reviewers were blinded to authors, journals and results of the studies. Disagreement or ambiguities were resolved by discussion with a third reviewer (KKPM).

Assessment of characteristics of trials

Quality

The quality of included trials was assessed by extracting PEDro Scale scores from the Physiotherapy Evidence Database (www.pedro.org.au). The PEDro Scale has 11 items, 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 (range 0 to 10 points). Where a trial was not included on the database, two reviewers, who had completed the PEDro scale training tutorial, scored it independently.

Box 1. Inclusion criteria.

Design
- randomised or quasi-randomised trials

Participants
- adults (> 18 years old)
- diagnosis of stroke
- respiratory muscle weakness (ie, < 90% normal maximal inspiratory or expiratory pressures)

Intervention
- respiratory muscle training aimed at increasing strength of the inspiratory and/or expiratory muscles

Outcome measure
- inspiratory and/or expiratory muscle strength

Comparisons
- respiratory muscle training versus nothing/sham respiratory intervention

Participants

To be eligible for inclusion, trials had to involve adult participants with respiratory muscle weakness following stroke. Participants were considered weak when the strength of their respiratory muscles, reported as maximal inspiratory or expiratory pressure, was < 90% of that predicted for age-matched and gender-matched healthy subjects.[7,18,19] To describe each included trial, the number of participants and their gender, age, time since stroke, and magnitude of respiratory muscle weakness were recorded.

Interventions

The experimental intervention was respiratory muscle training that produced repetitive contractions of the respiratory muscles against resistance in order to increase strength. The control intervention could be nothing or a sham intervention (ie, the intervention was not delivered with enough specificity (non-respiratory training) or dose (low-dose training) to have an effect).

Outcome measures

Five outcomes were of interest: respiratory muscle strength (inspiratory and expiratory), respiratory muscle endurance, activity, participation, and occurrence of respiratory complications.

The strength measurement had to be representative of maximum voluntary contractions generated during maximum resistance of inspiration or expiration (eg, maximal voluntary inspiratory pressure or maximal voluntary expiratory pressure).[20] When multiple measures of strength were reported, the measure that reflected the trained muscle(s) was used. If both expiratory and inspiratory muscles had been trained and measured, the mean (SD) of the two measurements were summed so that only data from independent groups were entered into the meta-analyses.[21,22] The endurance measurement had to be representative of the ability to breathe against increasing inspiratory or expiratory loads, or the ability to breathe at a fixed load during a predetermined amount of time (eg, 2-minute incremental load method).[7,20,23] The activity measurement had to be representative of the ability to execute tasks or actions, and the participation measurement had to be representative of the involvement of the individual in real-life situations.[24] Direct measures or self-reported questionnaires were used, regardless of whether they produced continuous or ordinal data. Measures of general activity (eg, Barthel Index) were used if they were the only available measure of activity. Measures of quality of life were used if they were the only available measure of participation. Occurrence of respiratory complications was defined as number of participants with diagnosis of respiratory complications (eg, lung infections and pneumonia) after training commencement.

Data analysis

Two reviewers independently extracted information regarding the method (ie, design, participants, intervention, outcome