Title: Inspiratory muscle training for improving inspiratory muscle strength and functional capacity in older adults: a systematic review and meta-analysis.

Abstract

Background: The ageing process can result in the decrease of respiratory muscle strength and consequently increased work of breathing and associated breathlessness during activities of daily living in older adults.

Objective: This systematic review and meta-analysis aims to determine the effects of inspiratory muscle training (IMT) in healthy older adults.

Methods: A systematic literature search was conducted across four databases (Medline/Pubmed, Web of Science, Cochrane Library CINAHL) using a search strategy consisting of both MeSH and text words including older adults, inspiratory muscle training, and functional capacity. The eligibility criteria for selecting studies involved controlled trials investigating inspiratory muscle training via resistive or threshold loading in older adults (>60 years) without a long-term condition.

Results: Seven studies provided mean change scores for inspiratory muscle pressure and 3 studies for functional capacity. A significant improvement was found for maximal inspiratory pressure (PI_{max}) following training (n=7, 3.03 [2.44, 3.61], p=<0.00001) but not for functional capacity (n=3, 2.42 [-1.28, 6.12], p=0.20). There was no significant correlation between baseline PI_{max} and post-intervention change in PI_{max} values (n=7, *r*=0.342, p=0.453).

Conclusions: IMT can be beneficial in terms of improving inspiratory muscle strength in older adults regardless of their initial degree of inspiratory muscle weakness. Further research is required to investigate the effect of IMT on functional capacity and quality of life in older adults.

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1.0 – Introduction

1.1 Background:

Respiratory function is reduced during the ageing process due to structural and physiological changes of the respiratory system [1]. These changes are characterised by decreased recoil pressure of the lung, respiratory muscle function and chest wall compliance [2]. During ageing we see a decrease in muscle mass, strength and function which can accelerate the decline in respiratory muscle strength in older adults assessed by maximal inspiratory pressure (PI_{max}) measurements [3]. Several studies in healthy older adults [4-6] have reported PI_{max} values as low as those reported in patients with lung or heart disease [6-8].

Decreased respiratory muscle strength leads to increased residual volume, functional residual capacity and consequently increased work of breathing and associated breathlessness during activities of daily living in older adults [9]. Therefore, exertional breathlessness in older adults may compromise an individual's daily functional capacity and quality of life [10].

Reduced respiratory muscle strength and functional capacity is often seen in patients with lung or heart disease [11, 12]. In these patients, an effective method to combat inspiratory muscle weakness is inspiratory muscle training (IMT). Several studies have been conducted investigating the effect of IMT in various respiratory [7, 13, 14] and cardiovascular disorders [8, 15, 16]. Previous meta-analyses have suggested that IMT can improve inspiratory muscle strength (reflected by an increase in maximal inspiratory pressure), six-minute walking distance (6MWD) and quality of life in chronic obstructive pulmonary disease (COPD) [17, 18] and chronic heart failure (CHF) [19].

Due to the age-related decline in respiratory muscle function, it is likely that IMT will also have a beneficial effect in an ageing population without a long-term condition. A recent systematic review has started to investigate IMT in healthy older adults with the authors suggesting a positive trend for IMT in improving inspiratory muscle strength [20]. It should be noted, however, that this review also included frail participants with comorbidities and extreme debilitation [21, 22] that could affect the magnitude of improvement in PImax. Accordingly, the present systematic review and meta-analysis focuses on the effects of IMT in healthy older adults without frailty or associated comorbidities given that in this population, reduced respiratory muscle strength is associated with a decline pulmonary function [23], reduced physical performance [24], and constitutes an independent risk factor for myocardial infarction and cardiovascular mortality [25]. Thus, interventions that increase respiratory muscle function may have an important clinical impact in healthy older adults.

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1.2 - Review objective:

To systematically review and perform a meta-analysis on the effects of inspiratory muscle training (IMT) for improving inspiratory muscle strength and functional capacity in healthy older adults.

2.0 – Methods:

2.1 Search strategy

This prospectively registered systematic review (CRD42019155163; https://www.crd.york.ac.uk/prospero/) followed the Cochrane Handbook for Systematic Reviews of Interventions [26] and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [27]. Electronic database (Medline/PubMed, Cochrane Library, Web of Science and CINAHL) were searched from August 2019 to February 2020.

The final search strategy included relevant MeSH Terms, Text Words and Publication Types relating to the population (e.g. "aged" and "older adults"), the intervention (e.g. "inspiratory muscle training" and "breathing exercises"), the outcomes (e.g. "exercise tolerance", "quality of life" and "maxim* inspiratory") and the design (e.g. "random*", "clinical trial" and "experimental study"). These terms were constructed and grouped by Boolean logic with no restrictions on publication date. The full PubMed search strategy can be found in Appendix 1.

2.2 – Inclusion and exclusion criteria:

MeSH Terms/Text Words including "frail elderly", "frail" and "frailty" were included in the search strategy due to the finding that, during pre-scoping, these keywords were associated with older populations with weaker inspiratory muscles undertaking IMT programmes [28]. The MeSH Term "breathing exercises" was also included as, during pre-scoping, it was found to be associated with inspiratory muscle training in some studies [6, 28-30]. Studies were considered eligible if they fulfilled the pre-determined participants, interventions, comparisons and outcomes (PICOS) criteria (Appendix 2).

Initial screening of titles and abstracts and assessment of full texts were performed independently by two authors (blinded for review) who were blinded to each other's decisions. Any disagreements between the authors were sent to a third author (blinded for review).

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2.3 – Data extraction:

2.4 **Data was extracted in terms of the following subheadings. 1) author information (first author and year of publication), 2) participant characteristics (age, gender, baseline maximal inspiratory pressure; PI_{max}), 3) mode of IMT and supervision, 4) time, intensity and progression of IMT, 5) frequency and duration of IMT, 6) control and 7) outcomes assessed.** –

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Quality Assessment:

The PEDro quality scale was used to assess internal and external validity of the included studies [31]. Two authors (blinded for review) independently reviewed each included study on the following domains of the PEDro scale: eligibility criteria, random allocation, concealed allocation, baseline similarity, blinding of subjects, therapist and assessor, measures obtained from more than 85% of subjects initially allocated to groups, full intention to treat, group comparison, and point measures and measures of variability. PEDro scale scores 9-11 were considered excellent, 6-8 good, 4-5 fair and ≤3 poor [31] . No study was excluded based on poor quality.

2.5 – Data analysis:

Meta-analyses of the studies were performed using the software Review Manager (RevMan V5.3; Cochrane Collaboration, Oxford, UK). Outcomes were continuous and change scores with standard deviations were used to obtain effect size reported as standard mean differences with 95% confidence intervals. The heterogeneity of studies were assessed by the I^2 value, and were classified as might not be important (0-40%), moderate heterogeneity (30-60%), substantial heterogeneity (50-90%), and considerable heterogeneity (75-100%) [26]. A small minimum clinically important difference (MCID) in functional capacity was observed if participants in the IMT groups improved their 6MWD by above 20m and a substantial MCID if the improvement was over 50m [32]. A random-effects model was used for the meta-analyses as variation in methods were found between included studies beyond random sampling. Pearson's correlation analysis was performed in order to determine the association between baseline PI_{max} and change in PI_{max} following IMT within included studies. The level of significance for all analyses was set at $p < 0.05$.

3.0 – Results:

The databases yielded 986 studies (Figure 1). Following the removal of 181 duplicates and screening of 805 titles/abstracts, 19 articles remained for full-text screening of which 11 were excluded. Overall, 8 studies were included in this systematic review with one of these studies [5] excluded from the meta-analysis due to insufficient data reported (Table 1). The full characteristics of included studies can be found in Appendix 3.

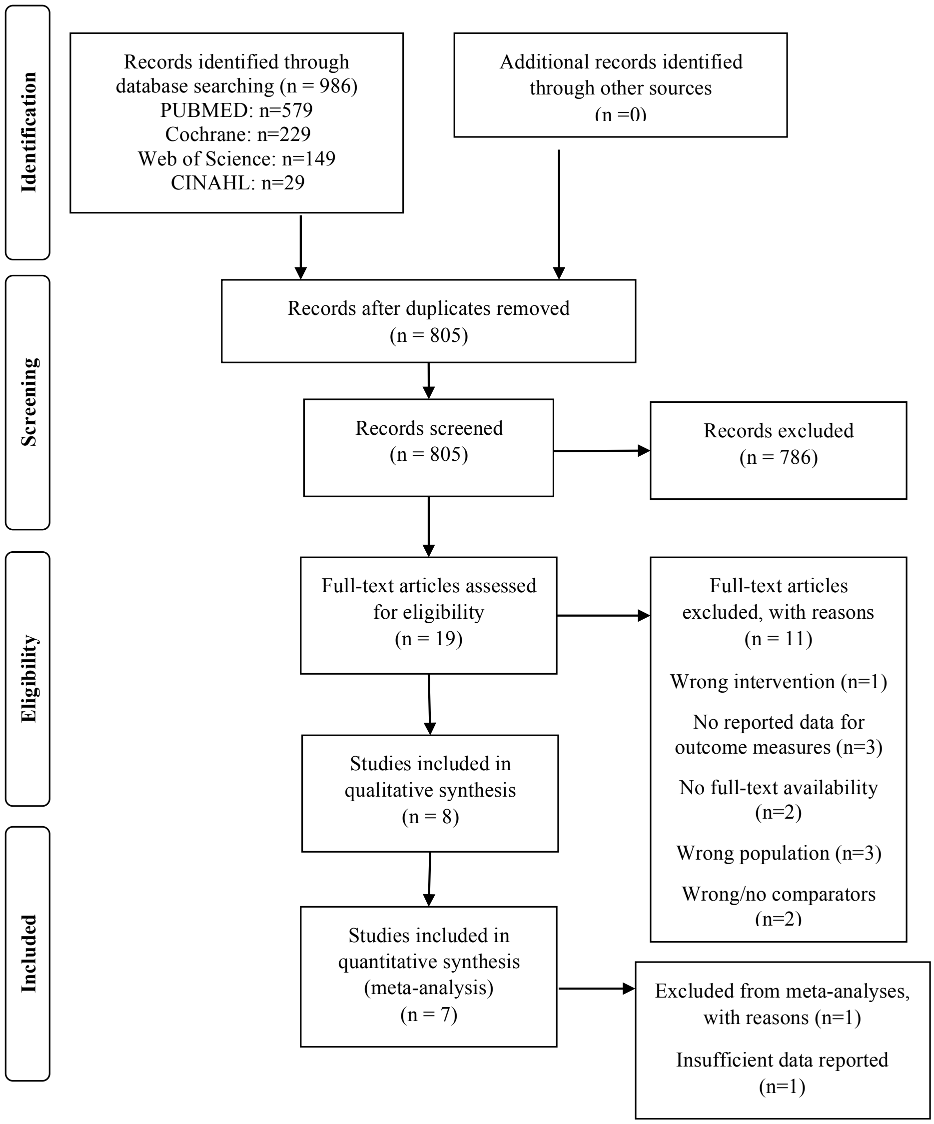

Figure 1. PRISMA flow diagram of studies through database search and selection process; n=number.