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Quality of resistance training description in COPD trials: study protocol for a systematic review

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ABSTRACT

Introduction Limb muscle dysfunction is a common manifestation in patients with chronic obstructive pulmonary disease (COPD). Optimising of limb muscle function is therefore an important goal during pulmonary rehabilitation of patients with COPD. Resistance training (RT) is the best available intervention to achieve this goal. Previous systematic reviews on RT primarily focused on methodological quality. However, the intervention holds the essence of each experimental study. Replication of RT interventions requires clear, complete and accessible reporting of the essential components. The American College of Sports Medicine (ACSM) provides evidence-based guidelines for RT prescription and recommends RT models specific to desired outcomes, that is, improvements in strength, muscular hypertrophy, power or local muscle endurance. The aim of this review is to investigate if the application of the RT principles and key training variables is described sufficiently in current evidence on the effects of RT interventions in patients with COPD.

Methods and analysis Any research study (randomised, non-randomised controlled, controlled pre–post studies and observational studies) with an RT intervention in patients with COPD will be considered for this systematic review. Potentially relevant studies published in English from inception to 1 October 2017 will be identified from Embase, Cochrane Library, Cumulative Index of Nursing and Allied Health Literature (CINAHL) and Physiotherapy Evidence Database (PEDro). Studies exploring the effects of RT following a single session and RT interventions limited to other respiratory chronic diseases will not be included. Additionally, studies including non-COPD participants will be excluded, if the COPD data are not separated. Pairs of reviewers will independently extract data using data collecting sheets. Quality appraisal of RT description will be performed in timeframes according to the latest published ACSM position statement on exercise or RT.

Ethics and dissemination This protocol is a systematic review and therefore ethical approval is not required. The results of this review will be disseminated through peer-reviewed publication and presented at scientific conferences.

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Strengths and limitations of this study

- This protocol is reported in line with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Protocols, and the systematic review (SR) will be reported in line with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Statement.
- The proposed SR will include all English language published descriptions of resistance training (RT) in clinical studies in patients with chronic obstructive pulmonary disease and will provide a broad overview of the quality of RT prescription.
- Exclusion of clinical studies published in other languages than English will leave potentially relevant information not known to the authors out of the review and this may bias the results.

INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is expected to be the third ranked cause of mortality by 2020.[1] COPD is primarily characterised by airway limitation. Nonetheless, many patients with COPD experience extrapulmonary consequences that may contribute to disease severity in individual patients. Limb muscle dysfunction is an apparent manifestation in the early stages of the disease process.[2] Recognised features include limb muscle weakness, muscle atrophy, reduction in muscle oxidative capacity (lower fraction of type I fibres, decreased capillary density and aerobic enzymes), type II fibre shift, all of which have prognostic significance independent of the degree of airway limitation and contribute to exercise limitation.[3–5]

The first American Thoracic Society (ATS) publications on the effects of exercise training during pulmonary rehabilitation (PR) in patients with COPD begun to appear in the 1980s.[6 7] These prior statements refer to whole-body, aerobic exercise as a means to improve exercise tolerance. Indeed, traditionally, aerobic exercise training has become the mainstay during COPD rehabilitation. This type of exercise training has well-established effects on patients with COPD with

improvements in quality of life and exercise capacity.[8 9] During the next decade, focus was shifted to the role of peripheral muscle weakness,[10] and its contribution to exercise limitation.[10–12] However, aerobic exercise training has little effect on muscle strength.[9 13] Resistance training (RT), on the other hand, has shown to improve muscle strength in patients with COPD.[14] Moreover, RT recruits small muscle groups and results in a lower burden on the ventilatory system with less resultant disabling dyspnoea compared with aerobic endurance training.[9 15] However, although it is stated that RT is a valuable strategy to improve muscle strength and muscle mass, the optimal RT prescription for patients with COPD has yet to be determined.[9 16]

Determination of the most optimal RT prescription in COPD is, however, more complicated as it appears at first sight. COPD limb muscle is characterised by a large heterogeneity of muscle phenotypes and muscle dysfunction.[17 18] This heterogeneity is related to exercise performance.[5] In advanced COPD, there is a predominant loss of type II muscle fibres which affects muscle mass and strength.[10] Moreover, COPD is characterised by a selective loss of type I muscle fibres and oxidative enzymes which affects the endurance function of skeletal muscle,[19] and is already observed in less severe COPD.[20] Therefore, these specific alterations in muscle function stress the importance of identifying those factors that should be considered in the development of individualised RT programmes in patients with COPD. Since RT allows appropriate and specific loading to limb muscle, it is deemed the most efficacious approach to ameliorate muscle dysfunction (eg, muscle strength and muscle endurance).[3 8 21]

Appropriate recommendations across the spectrum of muscle dysfunction based on results of RT interventions in patients with COPD require consistent and accurate reporting of the principles of RT prescription. Moreover, the components of the RT intervention should be reported with sufficient detail to guarantee intervention implementation and replication.[22]

The evolution of the present knowledge base of RT guidelines dates back to the post-World War II decades.[23–32] However, it lasted to the second half of the 1980s when the potential value of RT for health promotion and fitness was recognised by medical and scientific bodies.[33]

In 1990, the American College of Sports Medicine (ACSM) replaced their 1978 Position Statement on exercise training and added an RT component.[34] The ACSM provides evidence-based guidelines for individualised RT prescription in their subsequent published RT recommendations.[21 35 36] Due to the developments in RT research during the last two decades, it is regarded important to consistently incorporate the principles of RT progression: progressive overload, specificity and variation.[21 36] The principles of RT progression are shown and explained in table 1.[21] Moreover, reporting of the components of the RT intervention should include RT principles and should be done according to identified key training variables. The key RT variables that determine the demands placed on the body and affect muscle function and morphology are shown in table 2.[21 36]

Objectives

The objectives of this systematic review (SR) are (1) to investigate if the application of the RT principles and (2) the reporting of the key programme variables is described sufficiently in current evidence on the effects of RT interventions in COPD.

METHODS

The protocol for this SR is in line with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Protocols.[37]

Table 1 Principles of resistance training (RT) progression

RT principle	Definition for application
Progressive overload	Progressive overload is the gradual increase of stress placed on the body during exercise training. Systematically increasing the demands placed on the body is necessary for further improvement and may be accomplished through altering one or more key training variables (eg, exercise intensity, total repetitions, repetition speed, rest periods or training volume).
Specificity	Specificity is the physiological adaptation to the type of stimulus applied. The adaptations are determined by various factors (muscle groups trained, muscle actions used and energy systems involved).
Variation)	Variation (or periodisation) entails the systematic process of altering one or more programme variable(s) over time to allow for the training stimulus to remain challenging and effective.
Classical	Characterized by high initial training volume and low intensity, and as training progress, volume decreases and intensity gradually increases.
Reverse	The inverse where intensity is initially at its highest and volume at its lowest, in which, over an extended time, intensity decreases and volume increases with each phase.
Undulating (nonlinear)	Enables variation in intensity and volume within a cycle by rotating different protocols to train various components of neuromuscular performance.

Table 2 Key training variables for resistance training (RT)

Variable	Interpretation
Muscle actions	Most RT programmes primarily include dynamic repetitions with both concentric (CON; muscle shortening) and eccentric (ECC; muscle lengthening) muscle actions, whereas isometric (ISOM; no net change in muscle length) actions play a secondary role (eg, during non-agonist muscle stabilisation, core strength, grip strength, pauses between ECC and CON actions or specific agonist ISOM exercises).
Intensity (loading)	Include one or more of the following schemes for increasing load: 1. Based on a percentage of 1 RM; 2. Based on a targeted repetition number; 3. Within a prescribed zone (eg, 8–12 RM).
Volume	Summation of the total number of repetitions performed during a training session (repetition volume). Include altering by changing: 1. Number of exercises performed per session. 2. Number of repetitions performed per set. 3. Number of sets per exercise.
Velocity of muscle action	Velocity in seconds with ratio CON:ECC (eg, fast (<1:1), traditional (1:1), moderate (1–2:1–2), slow (5:5), very slow (10:5)) or based on breathing frequency.
Exercise selection	Multiple modalities (eg, free weights, machines, cords, etc) for targeted muscle groups can be performed in unilateral and bilateral single-joint and multiple-joint exercises. The used exercises should be specified (eg, leg extension, leg press).
Exercise order	The sequencing of exercises (eg, based on a prescribed regimen, agonist/antagonist or single-joint/multiple-joint, rotation of upper and lower body).
Rest periods between sets	The amount of rest between sets may vary based on the complexity of the exercise and therefore both should be specified. Longer rest periods for strength development (≥2–3 min) and shorter rest periods for improving muscle endurance (≤1 min).
Rest periods between exercises	The amount of rest between exercises may vary based on the complexity of the exercise and therefore both should be specified.
Frequency	Number of workouts per week.

RM, Repetition Maximum.

Inclusion and exclusion criteria

Any research study (randomised, non-randomised controlled, controlled pre–post studies and observational studies) with an RT intervention in patients with COPD will be considered for this SR. However, studies exploring the effects of RT following a single session and RT interventions limited to other respiratory chronic diseases will not be included. Additionally, studies including non-COPD participants will be excluded, if the COPD data were not separated. No restrictions will be placed on interventions in control groups. Studies referring to a protocol or a secondary study will be taken into account. Only papers published from inception to 1 October 2017 and written in English will be eligible for inclusion. Papers referring to methods described elsewhere will only be included if these references are published in English. The number of non-English publications will however also be reported.

Information sources and search strategy

To identify relevant studies, a comprehensive search of electronic databases will be performed. The original search strategy will be designed with the assistance of a librarian. The main PubMed/Medline search strategy based on a combination of relevant terms is shown in table 3. The proposed search strategy terms will be adapted for each electronic database, that is, Ovid (Embase), Cochrane Library Cochrane Controlled Register of Trials (CENTRAL), CINAHL (EBSCO) and PEDro. A manual search of reference lists of included studies and other relevant review studies will also be conducted to obtain additional papers.

Selection process

The results will be downloaded to Endnote X7 software to manage the records retrieved from the searches, and where duplicates will be removed.

Two reviewers (BW, PK) will independently review all titles and abstract to identify potentially relevant studies for inclusion based on the inclusion criteria. Each study is labelled 'include' or 'exclude' and agreement is examined. Studies will be labelled 'unclear' when inclusion or exclusion of a study could not be based on the screening of the title or abstract. Full-text articles for studies labelled 'unclear' will be independently screened by two reviewers (BW, PK) and subsequently included or excluded. Discrepancies will be resolved by consensus or by arbitration by a third author (SW). The results of the detailed selection process will be reported using the PRISMA flow diagram.[38] Missing papers will be requested from study authors.

Table 3 PubMed Medline search strategy

Search	Query
#1	'Exercise Therapy'[Mesh] OR resistance training[tiab] OR resistance exercise*[tiab] OR weight bearing exercise program*[tiab] OR strength training[tiab] OR strengthening program*[tiab] OR exercise training[tiab] OR [exercise[tiab] AND training[tiab]] OR weight-lifting strengthening program*[tiab] OR weight-lifting exercise program*[tiab] OR weight bearing strengthening program*[tiab]
#2	'Pulmonary Disease, Chronic Obstructive'[Mesh] OR chronic obstructive pulmonary disease[tiab] OR COPD[tiab] OR COAD[tiab] OR chronic obstructive lung disease[tiab] OR chronic obstructive airway disease[tiab] OR chronic airflow obstruction*[tiab] OR chronic bronchitis[tiab] OR pulmonary emphysema*[tiab]
#3	'Clinical Trial'[Publication Type] OR 'Randomized Controlled Trial'[Publication Type] OR 'Random Allocation'[Mesh] OR 'Cohort Studies'[Mesh] OR 'Case-Control Studies'[Mesh] OR 'Observational Study'[Publication Type] OR random*[tiab] OR trial[ti] OR RCT[tiab] OR RCTs[tiab] OR [clinical[tiab] AND trial[tiab]] OR observation*[tiab] OR cohort[tiab] OR prospective[tiab] OR retrospective[tiab] OR case-control[tiab]
#4	#1 AND #2 AND #3

Mesh, Medical Subject Headings; tiab, title/abstract.

Data extraction

Data extraction will be performed by one author (first reviewer) and four research and field expert authors (second reviewers). From each included study, the first reviewer and a second reviewer will independently extract data on a constructed form created for this study. Two reviewers will examine agreement, and disagreement will be resolved by consensus.

The following study characteristics will be extracted:

- Publication details: name of first author, publication year.
- Study objective: study design, goal of the study.
- Participants characteristics: number of participants, training status and inclusion criteria when specified: disease severity or Global Initiative for Chronic Obstructive Lung Disease (GOLD) classification, baseline forced expiratory volume in one second (FEV_1) and/or FEV_1/forced vital capacity, smoking status, comorbidity and/or other relevant inclusion criteria, age range.
- Intervention: description of intervention and control group, description of training device used, adjuncts (eg, administration of oxygen, non-invasive ventilation, Heliox, respiratory muscle training, downhill training, vibrating plates), place of RT in intervention (stand alone, part of PR, adjunct), RT objective, duration, supervision, setting (mixed, inpatient, outpatient, home based).

Table 4 Description of RT principles as applied

Study	Progressive overload	Specificity	Variation (three types of periodization)

N, no; Y, yes.

In addition, primary and secondary study outcome measures will be reported.

Quality appraisal of the exercise prescription

Data collection sheets are developed to evaluate application RT principles (table 4) and key training variables (table 5). Quality appraisal for each study is performed by the first reviewer and a second reviewer not involved in any of the included studies. Agreement will be examined, and disagreement will be resolved by consensus or a by consultation of a third author. Each RT principle and each training variable will be rated accordingly: yes (Y) 'reported', no (N) 'not reported'. Not applicable (NA) is used for 'exercise order' and 'rest between exercises' when only one RT exercise is used. Both key variables are NA in this context. 'Y' will be given a score of '1', 'N' a score of '0' and NA will be given no score. Sum scores of RT principles and key training variables per study will be calculated, and corrected for the number of NA used (ie, 7 instead of 9 key training variables). Percentages of studies complying with each RT principle and key training variable will also be calculated.

Published RT interventions should always have integrated the latest scientific developments and insights. Therefore, quality appraisal of RT description will be performed in timeframes according to the latest published ACSM position statement on exercise or RT.[21 34–36 39] Moreover, we will search for recommendations of major health organisations and key publications on RT to try to implicate the trends of time in our discussion on quality appraisal.

Patients and public involvement

Patients and the public were not involved in the design of this SR.

DISCUSSION

Previous SRs in COPD research were primarily focused on methodological criteria and efficacy.[40 41] These reviews have shown consistent and clinically important effects,

Table 5 Key training variables scored by presence

Study	Muscle actions	Intensity (loading)	Volume	Velocity of muscle action	Exercise selection	Exercise order	Rest periods: Between sets	Rest periods: Between exercises	Frequency	Sum score (possible maximum score other than 9)

N, no; NA, not applicable; Y, yes.

although no clear RT guidelines could be formulated. Clearly, it is evident that the design and methodological quality of clinical studies are thoroughly and accurately described to allow critical appraisal of study quality.[38] However, explicit information on the prescribed RT and the actual level of patient compliance by adequate supervision provides the best evidence with respect to the effects of RT interventions.[42 43] However, it is recognised that inclusion of all intervention information is not always possible due to restrictions in word allowance.[44] More recent publications might contain more detailed information due to the possibility to publish online supplements or trial protocols. Our findings will be interpreted with consideration of publication opportunities. In order to be able to evaluate the intervention quality, all details of RT interventions should be provided. The chosen RT protocol will have significant impact on study outcome.[45 46] Given the heterogeneity of muscle phenotypes and muscle dysfunction within the COPD population,[17 18 45] a detailed and comprehensive reporting on the RT principles and key training variables is necessary. Detailed information is important for clinicians and allied health professionals to draw valid conclusions, to implement RT interventions for the desired outcome and facilitate reproducibility by other researchers.[44] Statements on PR and Clinical Practice guidelines are used by clinicians to implement firm evidence-based interventions in clinical practice. Therefore, we will also discuss how RT recommendations are reflected in the official documents of the ATS and the European Thoracic Society, and the formulated practice guidelines.

To our knowledge, this is the first SR with a comprehensive synthesis of existing evidence on the quality of RT description in COPD trails. Our SR has important strengths, since the protocol is reported in line with the PRISMA Protocols, and the SR will be reported in line with the PRISMA Statement. The proposed SR will include all English language published descriptions of RT in clinical studies in patients with COPD and will provide a broad overview of the quality of RT prescription. However, as clinical studies published in English are eligible for inclusion, potentially relevant information from publications in other languages may leave relevant information out of the review. Therefore, the number of non-English publications will be addressed in the discussion on our findings.

CONCLUSION

The results of this project will provide important information to guide the design of future RT interventions and clinical work in patients with COPD. Reporting of the RT prescription with sufficient detail can produce evidence-based recommendations for a minimum set of key RT variables and improve RT prescription in future PR guidelines.

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Patient consent for publication Not required.

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