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Published in:
Frontiers of Nursing

DOI:
10.2478/fon-2021-0012

Published: 01/06/2021

Document Version
Publisher's PDF, also known as Version of record

Frontiers of Nursing • 8(2) • 2021
DOI: 10.2478/fon-2021-0012

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Frontiers of **Nursing**

Evaluation of the intervention of home-based pulmonary rehabilitation in patients with chronic obstructive pulmonary disease

Review

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Received: 11 September 2020; Accepted: 21 November 2020; Published: 20 June 2021

Abstract: **Objective:** Chronic obstructive pulmonary disease (COPD) can be prevented and treated, although presenting with persistent airflow restriction; the airflow restriction caused by COPD is mostly progressive. In recent years, more attention has been paid to the home-based pulmonary rehabilitation (PR) and its influence on COPD. Exercise training is the basic constituent of PR. However, it is not clear which exercise trainings are the ideal ways to deliver home-based PR.

Methods: In this review, we focus on the effect of home-based exercise training on patients with COPD. We searched literature, which was necessarily required to be randomized controlled trails (RCTs) from the establishment of the four respective databases (Medline, PubMed, Web of Science, and China National Knowledge Infrastructure) from January 2008 to January 2018. We used the Cochrane collaborative "risk of bias" tool to assess the quality of evidence. A total of 21 trials (1694 participants) were included. Through the analysis of the literature, we find that a simple, low-cost, and low-intensity family-based lung-rehabilitation plan to adapt to the real life may lead to the improvement of the ability to exercise, the reduction of the difficulty in breathing, and the improvement of carrying out daily activities.

Results: In the exercise training of home-based PR, lower limb exercise (LLE) training demonstrated a more perceptible effect in improving the quality of life of patients with COPD. At the same time, the combination of LLE training, breathing training, and upper limb exercise training is more obvious than the simple LLE training. In addition, home-based low-intensity aerobic training may sometimes be no less than the outpatient or center intervention to improve dyspnea, health status, and exercise tolerance. In conclusion, the simple and easy home-based PR exercise program is useful. Long-term home-based PR may require an enhanced need for maintenance.

Conclusions: A simple, low-cost, and low-intensity high blood pressure response (HBPR) plan to adapt to the real life may lead to an augmentation in the ability to exercise, a reduction of the difficulty in breathing, and an improvement in carrying out day-to-day activities. HBPR strategies can benefit patients (elderly patients with COPD at home) in the long term.

Keywords: *chronic obstructive pulmonary disease • exercise training • home-based pulmonary rehabilitation*

# Ye Zhang and Na-Ping Xu are co-first authors and they contributed equally to this study.

How to cite this article: Zhang Y, Xu NP, Mo BR, Liu XL, Lin YC. Evaluation of the intervention of home-based pulmonary rehabilitation in patients with chronic obstructive pulmonary disease. *Front Nurs*. 2021;2:99-112.

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1. Introduction

According to the study published by the World Health Organization, chronic obstructive pulmonary disease (COPD) is expected to account for the fifth place in the world's economic burden by 2020.[1–3] COPD is a common disease with persistent airflow restriction that can be prevented and treated, and its airflow restriction is mostly progressive.[4] The main symptoms of COPD are dyspnea, fatigue and reduced physical activity, progressive aggravation, and spiral of symptoms, which seriously affect the patient's labor and quality of life.[5,6] Therefore, pulmonary rehabilitation (PR) has become an important part of the treatment of patients with COPD.[6,7]

PR has become the most effective nondrug intervention in improving kinetics and the state of health in patients with COPD, even in the presence of very severe disease condition.[8] An increasing number of reports show that supervised and trained PR programs improve endurance of muscle exercise, quality of life, activity of daily life, respiratory symptoms, and dyspnea. However, regular visits to hospitals or clinics may result in a patient's inability to comply with or reduce compliance, which is often a primary obstacle to the success of these programs. Another approach, therefore, is to consider a home-based rehabilitation program, which may be an effective way of delivery.

Recently, some systematic reviews of the research focus on the effectiveness and safety of home-based PR inpatients with COPD.[9,10] The results of some reviews show that home-based PR program can be an effectual, easy, cheap, and effective program to reduce fatigue and improve abilities of daily living (ADL) and quality of life (QOL) in COPD patients. Movement training is the basis of PR and is the effective method to improve the muscle function and chronic respiratory symptoms in patients with COPD.[11,12] However, those reviews did not focus on interventions of home-based exercise training. What kind of PR exercise intervention can not only achieve certain rehabilitation effect but also be better accepted by patients, to improve exercise compliance? Through the analysis of 21 selected articles, we classified these PR interventions and studied the rehabilitation effects of different intervention methods on patients. Therefore, the innovation of this study is to: (i) discuss the current family movement training for patients with COPD from the aspects of intervention type, content, method, and results; and (ii) provide the basis for the direction of the future family rehabilitation research.

2. Methods

2.1. Search and select procedures

Search for literature on home-based PR. The keywords used are "COPD," "COAD," or "chronic obstructive pulmonary disease" and "home-based pulmonary rehabilitation." It includes four relevant databases (PubMed, Web of Science, Medline, and China National Knowledge Infrastructure) established from January 2008 to January 2018. According to the predetermined selection and exclusion criteria, the qualification and selection of the article are evaluated by screening and obtaining the complete text. The selection procedures of studies are presented in a PRISMA flowchart (Figure 1).

2.2. Inclusion and exclusion criteria

The research included in this review must meet the following criteria: articles published in English or Chinese (the language used by the author) were searched in four databases from June 2008 to June 2018. The study focused on home-based lung-rehabilitation interventions and measured results in patients with COPD. Reviews, editorial, literary reviews, and conference papers are not included in this review.

The criteria for inclusion in this review were:

Focuses: (1) patients with COPD, (2) home-based PR, and (3) articles published from 2008 to 2018.

Type of studies: RCT

The criteria for exclusion were (1) editorial, (2) literature review, (3) PR not at home but in community or hospital, (4) focus on self-management, and (5) patients without COPD.

The selection procedures of studies are presented in a PRISMA flowchart (Figure 1).

2.3. Appraisal of the quality of the included studies

The "bias risk" of Cochrane collaboration was used to appraise the quality and bias risk of each article included in RCT. The tool assessed seven specific domains: generation of the random sequence, assignment of concealment, blindness for the subject and the intervention provider, blind method of the results assessment, incomplete data, and selectivity of the result report, which can be assessed as "low-bias risk," "high-bias risk," or "not clear bias risk.

According to the judgment standard criteria (Cochrane Handbook for Systematic Reviews of Intervention. Part 2:8.5), in the case of a systematic review of the intervention, if there is no data in the test, further information can be collected by contacting the original author.

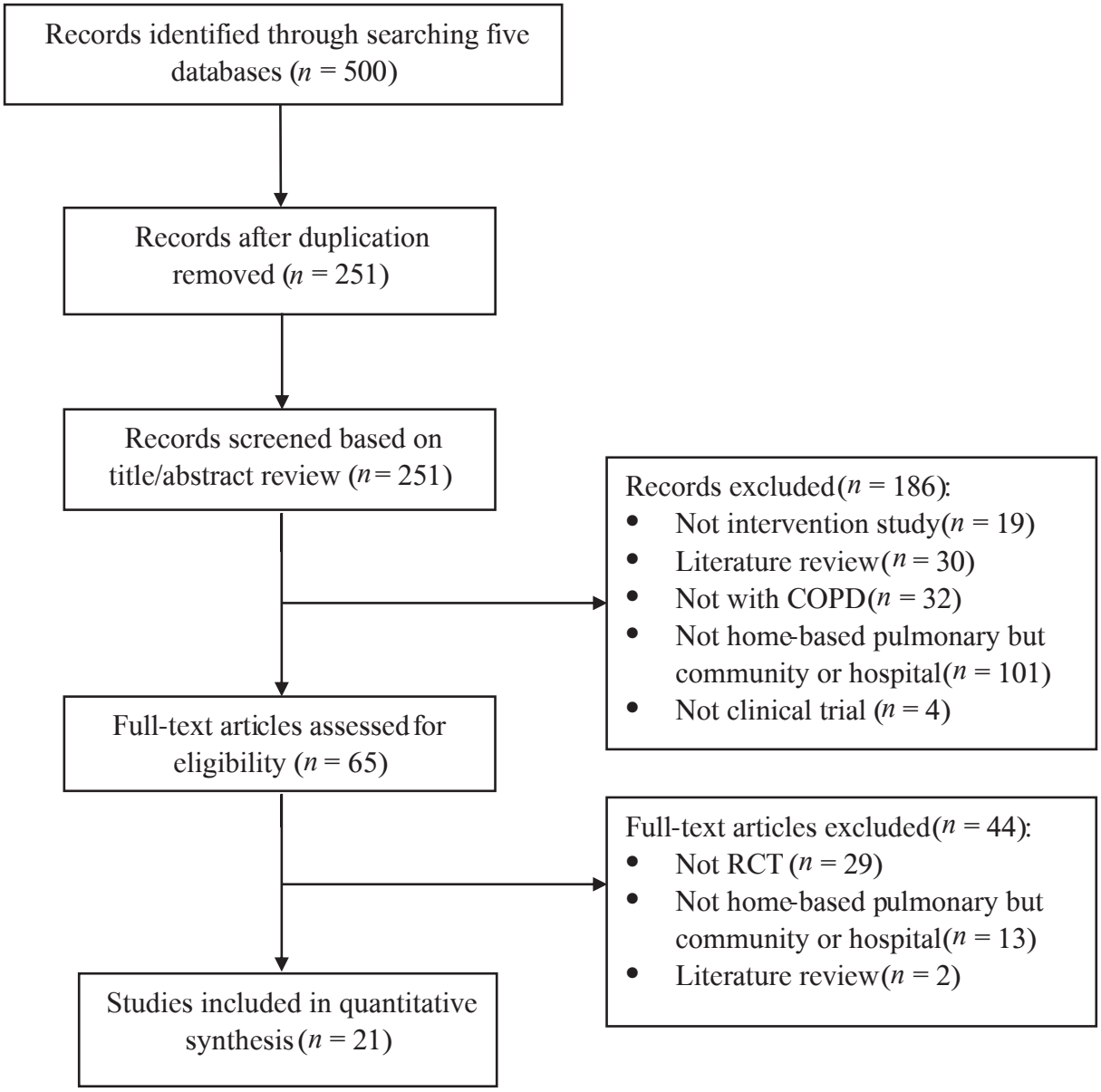

Figure 1. PRISMA flowchart.

2.4. Statistical analysis

The meta-analysis was performed using ReviewManager5.3 software provided by the Cochrane Collaboration. If data cannot be converted or merged, a descriptive analysis is used.

2.5. Data extraction and quality evaluation

In the initial extensive search, the two reviewers separately evaluated the titles and abstracts of all potentially germane articles by strictly complying with the inclusion/exclusion criteria and the differences in research options. The two researchers independently extracted the following data from all included studies: health-related quality of life (HRQOL) score, dyspnea, exercise ability, exercise tolerance, pulmonary function, anxiety and depression, adverse events, etc. They resolved the differences through discussions until a consensus was reached.

3. Results

3.1. Characteristics of the interventions

All 21 studies focused on home-based PR interventions in 14 countries and regions, namely, the USA

(*n* = 3, 14.3%), China (*n* = 2, 9.5%), Taiwan (*n* = 2, 9.5%), Spain (*n* = 2, 9.5%), Brazil (*n* = 2, 9.5%), The Netherlands (*n* = 2, 9.6%), Australia (*n* = 1, 4.8%), Germany (*n* = 1, 4.8%), Iran (*n* = 1, 4.8%), Italy (*n* = 1, 4.8%), France (*n* =1, 4.8%), UK (*n* = 1, 4.8%), Britain (*n* = 1, 4.8%), and Japan (*n* = 1, 4.8%). The 21 studies were randomized controlled trials (Table 1).

3.2. Target population

In these studies, the size of the sample ranged from 20 to 287 patients, with a total of 1694 patients. The wear rate is 0–49.5%, with an average of 23.6% (400/1694). The reasons why patients refuse to participate in or withdraw from home-based PR are (1) the causes of illness, such as acute exacerbation of COPD or deterioration or complications, or suffering from another illness or death, which affects PR training,[13–27] (2) loss of visit,[15,18,21–23,28] and (3) lack of cooperation.[15–17,21,22,24,27,28] There are also other factors, such as time conflict,[14] difficulty in operating instruments,[13] and entering into another maintenance procedure.[17] There are also traffic problems in central PR.[13] Some articles only mention the number of dropouts without explaining the reasons for dropping out.[29–32] One article mentions that one dropout is due to death, whereas others do not explain the reasons for drop out.[27] Another article[33] does not explain dropouts. Most of the home-based PR patients in these intervention studies were middle-aged and elderly, ranging in age from 40 to 80 years. Two other articles dealt with young and middle-aged people whose age requirements were >18 years (Table 1).

3.3. Theoretical framework of the interventions

Most of these theoretical frameworks focused on the comparison of two PRs, including the home-based pulmonary and the central-based PR,[15,16,21,22,28] and the home-based PR[13,14,17–20,23–27,29–33] Moreover, there is an article that compares home-based PR with central-based PR and family routine rehabilitation.[32] In these articles, the control group's family routine rehabilitation usually refers to conventional treatment care with or without respiratory training. Routine treatment care refers to drug therapy and health education. Drug therapy refers to the use of bronchodilators, anticholinergic drugs, cough relieving expectorant drugs, and so on. Health education refers to COPD's disease knowledge, smoking ban, diet, medication, prevention and treatment of acute attack, rest, and so on. Breathing training usually refers to lip breathing and abdominal breathing. The control group family/central PR involved in these articles refers to the addition of some rehabilitation exercises on the basis of conventional rehabilitation, such as aerobic exercise, endurance training, upper limb exercise (ULE), lower limb exercise (LLE), and relaxation training (Table 1).

3.4. Intervention approaches and focuses

The mode of intervention can be divided into two major categories, namely regulatory[15,18–22,24–33] and unsupervised,[13,14,16,17,23] with supervision including: telephone supervision—checking and urging patients' to exercise through regular telephone conversations; follow up regularly—physical therapists visit home regularly to check the condition of patients' exercise and give further guidance to them.[19,26,27,29,31] Time supervision meeting—patients do diary records at home, and regularly return to the center to meet with physiotherapists.[18,20] Unsupervised—usually refers to the unified guidance to the patient before the intervention and giving out the pamphlets; the patient exercises according to these instructions at home, during the no-appointment period. What form of supervision is followed? The means of interventions are divided into instrumental[13–15,17,18,26–28,30] and noninstrumental.[16,19–25,29,31–33] Instrumental assistance generally includes the following elements: walking with endurance to the music on a cell phone or other instruments for maximum endurance walking[13,14]; walking through a pedometer which[17,26] provides guidance, this instrument is also used to detect heart rate[28]; combining with home ventilator to carry out PR[18,27]; inhalation and atomization inhalation[30]; and lending portable ergo cycles that could adjust the resistance manually.[15] No instrumental assistance usually refers to PR exercises without any instrumental assistance (Table 1).

3.5. Dosage of interventions and follow-up time frame

In some articles, the duration of intervention is about 28.6 min (ranges from 15 to 70 min) with an average frequency of 4.7/week (range 2/week 7)[14–19,21–25,27,32,33]; some articles determine the duration of each exercise based on the intensity of the set of exercise targets;[13,26,28,31] and in some articles, the intervention changes and adjusts according to the tolerability of subjects.[20,29,30]

Different follow-up period also showed in the Table 1: 12 months (*n* = 5, 23.8%), 6 months (*n* = 4, 19%), 4 months (*n* = 1, 4.8%), 3 months (*n* = 5, 23.8%), 2 months (*n* = 3, 14.3%), 10 weeks (*n* = 1, 4.8%), and 7 weeks (*n* = 2, 9.5%).

Author/year/country or region	Subject characteristics	Intervention	Control	Time points	Measuring tools
Daniel Langer/2015/ USA	C: 10 I: 10 Age: >75 Stable COPD	MTL IMT —mechanical threshold loading (MTL)	TFRL IMT — tapered flow resistive loading (TFRL)	8 weeks	-Inspiratory muscle strength -Inspiratory muscle endurance -PF
Dimitra Nikoletou/2015/Britain	C: 34; I: 34. Stages: moderate to severe Age: >50 years	BE IMT with a threshold loading device	Not to train the respiratory muscles	7 weeks	-PImax -SNIP -diaphragm contractility (Pdi,tw) -ISWT -RME -CRDQ -HADS -the SF-36
Fahrahnaz Mohammadi/2015/Iran	40 patients: I: 20 C: 20 Stages: GOLD 2–3 Age: no limit	EDU+LLE+BE Three one-hour sessions of face-to-face + the correct methods of walking + drug therapy	Drug therapy.	7 weeks	-SF-12 -FSS -BI
Marieke L Duiverman/2011/The Netherlands	I: 24 C: 32 Stages: III or IV Ages: 40–76	EDU 12 weeks NIPPV+PR	At home: EDU 12 weeks PR	6, 12, 18, 24 M	-CRQ -MRF-28 -GARS -HADS -FEV1 -MRC -6MWD
María Rosa Güell/2007/Spain	51 patients: I: 23 C: 28 Stage III Age: I: 66 (5.8) C: 63.2 (6.6)	EDU+ BE\ULE\LLE: unsupervised street walking daily at a pace of 4 km/h marked by a podometer went up and down stairs for 5 minutes before and after each walk	Hospital: EDU+ BE\ULE\ LLE:	3 times per week	Respiratory muscle function. Arm muscle exercise tests. Leg muscle exercise test. CRQ
Juliana M. de Sousa Pinto/2014/Spain	I: 29 C: 21 Stages: severe and very severe Age: <80	BE+ULE+LLE Endurance training: walking, stair climbing, cycling. standard medical therapy + inhaler devices and nebulizer therapy.	At home: standard medical therapy + the nursing counseling session.	12 weeks	-The Spirometer Jaeger MasterScope model -SGRQ -LCADL -6MWD -The Borg scale -a pulse oximeter
Atsuyoshi Kawagoshi/2014/Japan	I: 20 C: 19 Stage: stable Age: Elderly aged	BE+ULE+LLE PR + pedometer use	At home: BE+ULE+LLE PP	1 Y	-CRQ -BODE -6MWD -FVC -FVC1

(*continued*)

Author/year/country or region	Subject characteristics	Intervention	Control	Time points	Measuring tools
Tristan Bonnevie/2018/France	C: 27; I: 24 Stages: severe to very severe Age: >18 years	BE+ULE+LLE NMES	Outpatient or home: EDU+BE+ULE+LLE muscle strength training	8 weeks	-6MWT -VO2peak -Wmax -mMRC -SGRQ
Xujingjuan/2016/China	C: 62; I: 63 Stages: modified or above	BE+ULE+LLE Improved lung-rehabilitation training program (including breathing training + routine care) + relaxation training +LLE +ULE	BE including breathing training + routine care	12 weeks	-6MWT -mMRC -PF -SGRQ
Fernanda Dultra Dias/2013/Brazil	I: 13 C: 10. Stages: stable Age: >40	EDU+BE+LLE a protocol at home with aerobic and muscle strength exercises	EDU only instructions to perform breathing and stretching exercises	2 M	-ISWT and VLIT -strength and endurance test (MIP and MEP) -AQ-20
W-T. Liu/2008/Taiwan, China	48 patients: I: 24 C: 24 Stages: moderate to severe Age: 40–80 years	LLE: Walking at a speed following the tempo of the music	At home: same protocol and take daily walking exercise	4 weeks for 3 M and again after 1 yr	-PF -ISWT -SF-12 -BMI
Chiung-Fang Ho/2012/Taiwan, China	41 patients: I: 20 C: 21 Stage II–III Age: 74 ± 10.3 years	LLE: The paced walking to music.at initial speed was set at 80% VO2 peak and increased gradually.	At Home: Receive the usual care.	12 weeks	-ISWT -PFT -HRQOL -SGRQ -Health resource utility
Marcel du Moulin/2009/Germany	20 patients: I: 10 C: 10 Stage: moderate Age: I: 67 (63–72) C: 72 (69–77)	EDU+3W Receive an individualized training plan. LLE: daily activities. (walking) with a pedometer	EDU+3W carry out their activities of daily living in their accustomed way.	after 3 M and 6 M.	-CRQ -PFT -6MWT
Elizabeth J Horton/2017/UK	C: 142 I: 145 Stages: 2–5 Mean age: 68	LLE Structure unsupervised home exercise	Center-based exercise: LLE	7 W;6 M	-CRQ-SR-HADS -PRAISE-ISWT -ESWT
P.de Roos/2016/Holland	C: 26 I: 26 Stages: Stable and moderate Mean age: 69.4 and 71.0	LLE 10 week supervised exercise training and home-based walk.	Center-based: standard medical care	10 weeks	-The accelerometry -Physical Activity Scale for the Elderly; -6MWT; -CRQ; -Exercise Self-Regulatory Efficacy Scale

(*continued*)

Author/year/country or region	Subject characteristics	Intervention	Control	Time points	Measuring tools
Wangxin/2013/China	I: 17 C: 18 Stages: very severe Age: 58–74 years	LLE+ Oxygen therapy + drug therapy + noninvasive positive Exercise under pressure ventilation	Oxygen therapy + drug therapy	6 M	-6MWD -Brog -SGRQ
Cristiane O Pradella/2015/Brazil	I: 29 C: 15 Age: 40–75 yearrs	LLE+ULE (1) warm-up, (2) aerobic activ-ity, (3) stretching, and (4) relaxation.	At home: no intervention.	8 weeks	-SGRQ -6MWT -treadmill endurance test - spirometry
Júlio C/2010/Italy	85 patients: HOME: 33 Outpatient: 29 C: 23 Stage: GOLD I–IV Age: H: 66.4 ± 9.5 O: 71.3 ± 6.7 C: 70.8 ± 8.7	(1) EDU LLE+ULE Aerobic=walks on flat ground and strengthening exercises (2) Outpatient: EDU ULE+LLE aerobic and strengthening exercises	(3) C: At home Not perform any PR	three mornings a week for three months.	-BMI -6MWT -BODE -mMRC dyspnea scale
Anne E Holland/2016/Australia	C: 86 I: 80 Stages: stable Mean age: 69	Structure Home Exercise (aerobic\LLE) with Physical Therapists Visiting and Telephone Supervision	Outpatient: twice weekly outpatient group-based supervised program,	8 weeks 1 Y	-6MWD -modified Medical Research Council dyspnea scale -CRQ -PRAISE -HADS
François Maltais/2008/America	252 patients: I: 126 C: 126 Stages: II–IV Mean age: 66	EDU+ Aerobic and strength exercise: ?	Outpatient: EDU+ LLE: Leg cycling	8 weeks	-CRQ -SGRQ -PFT -6MWT
Carol McFarland, P T/2012/America	I: 13 C: 11 Stages: Mild and moderate Mean ages: 72.2 and 76.2	Home visits +EDU A: aerobic conditioning	Home visits +EDU B: At home: functional strength training	8 weeks 16 weeks	-CRQ -Geriatric Depression Scale (GDS) -2MWT

Abbreviations: 6MWD, 6-minute walking distance; 6MWT, Six-minute walk test; CRQ, Respiratory Questionnaire; IMT, inspiratory muscle training; LLE, lower limb exercise; MTL, mechanical threshold loading; NIPPV, noninvasive intermittent positive pressure ventilation; NMES, neuromuscular electrical stimulation; PA, physical activity; PR, Pulmonary rehabilitation; SGRQ, Saint George's Respiratory Questionnaire; TFRL, tapered flow resistive loading device; ULE, upper limb exercise; mMRC, modified Medical Research Council; HADS, Hospital Anxiety and Depression Scale.

Table 1. Baseline characteristics of included studies.

3.6. Delivery of interventions

The intervention in these articles with or without supervision is trained by a physiotherapist or professional medical staff, and all these studies have formulated and followed a special intervention program and included regular checks in the entire intervention program to maintain the standard of treatment.

The intervention of the nearly 1/3rd of the articles was delivered to the combination of the intervener and the patient's face-to-face and telephone conversation, and nearly 1/5 (*n* = 4, 19%) was delivered with a combination of face-to-face and diary contacts between the intervener and the patient; and the intervention of the nearly 1/5th of the articles was delivered to the intervention group with three groups of face-to-face, telephone, and diary contacts with the patient. Combined to deliver (*n* = 4, 19%), there are other interventions that are delivered by the intervener to the patient's face-to-face (*n* = 3, 14.3%) and the diary to contact (*n* = 2, 9.5%), respectively; in addition, the intervention of an article[26] is delivered to the log of the pedometer (*n* = 1, 4.5%) (Table 1).

3.7. Outcomes of the intervention

3.7.1. Inspiratory muscle training program

Two of the RCTs report means of intervention of inspiratory muscle training (IMT) program. One of the trials showed that multiple tests have evaluated the change in muscle function after IMT, with greater cohesiveness.[31]

The other trial was to compare the effects of traditional IMT or TFRL regimens on the function of the inspiratory muscle in patients with COPD. The result showed that the short-term and home-based IMT scheme can effectively improve the function of inspiratory muscle in both groups. Compared with MTL group, the subjects of the TFRL group were subject to higher training load, and the function of the inspiratory muscle was significantly improved.[20] All of the trials reported significant improvement on inspiratory muscle function through the IMT intervention (Table 2).

3.7.2. Lower limb exercise program

There are 6 RCTs that use LLE training alone in family lung-rehabilitation such as walking training. There were two studies that assessed daily endurance walking by following the rhythm of music with an 80% oxygen uptake (VO2) from a program installed on a mobile phone. The results showed that the Incremental Shuttle Walking Test (ISWT) distance and endurance walking time in the intervention group were significantly improved. ISWT distance, inspiratory ability, and quality of life continued until the end of the study, whereas acute aggravation period and hospital stay decreased.[13,14] Four of the trials compared home-based intervention with the usual care, and the results indicated that home-based LLE with or without add-on intervention was more effective (measured by CRQ, SGRQ, ISWT, etc.) than the usual care.[13,14,17,27] Compared with center-based interventions, two trials showed that standardized family rehabilitation programs were comparable and not inferior to supervised central rehabilitation programs.[22,23] One trial showed that noninvasive intermittent positive pressure ventilation (NIPPV) in patients with COPD was significantly improved compared with routine treatment[27] (Table 2).

3.7.3. Breathing exercise and lower limb exercise programs

Two of the RCTs reported the intervention of breathing exercise (BE) and LLE at home.[18,33] One of the trials found that the average scores of tiredness were evidently lower in the test group ($P < 0.001$) after home-based PR in the test group, while the average scores of ADL ($P < 0.001$) and QOL ($P < 0.001$) were significantly improved after home-based nursing PR in the test group. Home-based PR can be an effective, cheap, and available regimen to decrease tiredness and improve ADL and QOL in COPD patients.[33] In addition to BEs and LLE, one of the trials reported that adding NIPPV to PR for two years in COPD patients with chronic hypercapnia could improve HRQOL, difficult breathing, hypofunction of lung, mood, and exercise tolerance. As time goes on, the gain is further increased[18] (Table 2).

3.7.4. Lower limb exercise and upper limb exercise programs

Three of the RCTs reported using upper limb movements and lower limb movements as means of lung-rehabilitation. One of the trials indicated that home-based PR program provided incremental effect by 65 m in the 6MWT ($P < 0.05$) and 316.6 ± 81.8 m in the endurance test ($P < 0.05$) and was reduced by >4 units in all SGRQ domains.[25] Two of the trials indicated that home-based and self-monitoring PR group is as effective as outpatient PR, and it is an effective choice for the treatment of patients with COPD[21,28] (Table 2).

Author/year/country	Intervention						Control		Outcome					
	EDU	BE	LLE	ULE	Aerobic/ Resistance exercise	Add-on	Our patient or hospital	Home	HRQOL	Dyspnea	Physical activity /*Exercise capacity*	PF	Anxiety/ Depression	Others
Daniel Langer/2015/ America	–	√	–	–	–	MTL	–	TFRL	–	–	–	PF: no improvement and no difference (both groups) PIMAX (inspiratory muscle strength) and Tlim (inspiratory muscle endurance)√ (TFRL>MTL)	–	–
Dimitra Nikoletou/2015/ Britain	. –	√	–	–	–	Device	–	No training	SF-36√ (emotion, mental, health)	–	ISWT: No difference between groups	PImax (r=0.6, $P = 0.04$)√	HADS√ ($P = 0.03$) Perception of wellbeing√	–
Fahrahnaz Mohammadi /2015/Iran	√	√	√	– .	–	–	–	Drug therapy	SF-12 (21.94 vs 54.63, $P < 0.001$)	–	Fatigue √FSS (21.94 vs 54.63, $P < 0.001$)	–	–	BI (95.55 vs 80.88, $P = 0.001$) ADL:√
Marieke L Duiverman/2011/ The Netherlands	√	√	√	–	–	NIPPV	–	BE+LLE	CRQ [96.8 (15.3) vs. 87.1 (18.9)]; $P = 0.044$√ MRF-28√	MRC√	GARS (−3.8 points (−7.4 to −0.4; $P = 0.03$))√ 6MWD√ (77.3 m (46.4 to 108.0; $P < 0.001$)	FEV1√ (115 ml (19 to 211; $P = 0.019$)).	HADS√ (−7.8 to 0.0; $P = 0.05$)	–
María Rosa Güell/2007/Spain	√	√	√	√	–	–	√	–	CRQ I:Dys:√ C: All HRQOL scores were higher in hospital training	–	6MWT: increased but no difference. Arm strength: had improved and not difference.	PImax Both groups had improvement	–	–
Juliana M. de Sousa Pinto/2014/Spain	–	√	√	√	–	–	–	Standard medical therapy	I: SGRQ ($P < 0.001$) √ Activity domain ($P = 0.008$) Impact domain ($P < 0.001$)	I: LC-ADL ($P < 0.01$)√ Improve breathlessness C: No difference	I 6MWD: ($P = 0.008$)	–	–	–
Atsuyoshi Kawagoshi/2014/ Japan	–	√	√	√	–	Pedometer	–	BE+ULE+LLE	(Both groups) CRQ (r = 0.540, $P = 0.004$)√	BODE (r = 0.656, $P = 0.001$) MRC:√(PR+P)	(both groups) 6MWD (r = 0.401, $P = 0.038$)	Both group: Imax√	–	Qf\walking time√(PR+P)

(*continued*)

Author/year/country	Intervention						Control		Outcome					
	EDU	BE	LLE	ULE	Aerobic/ Resistance exercise	Add-on	Our patient or hospital	Home	HRQOL	Dyspnea	Physical activity /*Exercise capacity*	PF	Anxiety/ Depression	Others
Tristan Bonnevie/ 2018/France	–	√	√	√	–	NMES	–	EDU+BE+ ULE+ LLE+ Muscle strength training	SGRQ ($P = 0.01$)√ (both groups)	mMRC ($P < 0.01$) (both groups)	6MWT: ($P < 0.01$) (both groups)	–	–	–
Xujingjuan/2016/ China	–	√	√	√	–	–	–	BE	SGRQ ($P < 0.05$)	mMRC√, $P < 0.05$	6MWT, $P < 0.05$	–	–	–
Fernanda Dultra Dias/2013/Brazil	√	√	√	√	–	–	–	EDU+BE+ stretching exercises	– not improved	–	ISWT: no difference (both groups)	Respiratory endurance improved in I group.	–	Biweekly supervision plays important role
W-T. Liu,/2008 /Taiwan	–	–	√	–	–	Music	–	LLE	Sf-12√	Dyspnea rating Borg scale	ISWT√	–	–	Clinical outcomes: Endurance walking exercise compliance
Chiung-Fang Ho/2012/Taiwan	–	–	√	–	–	Music	–	Usual care	SGRQ: √	Borg scale RPE-D Resting dyspnea√ Fatigue√	ISWT:√	No differential change	–	–
Marcel du Moulin/ 2009/Germany	√	–	√	–	–	–	–	Usual care	CRQ:√($P = 0.027$) CRQ (dyspnea)√ ($P = 0.014$) CRQ (fatigue)√ ($P = 0.016$)	–	6MWT √ 6MWT in meters (primary end-point, p = 0.033	FEV1: $P = 0.007$	–	–
Elizabeth J Horton/2017/UK	–	–	√	–	Resistance exercise	–	Center: LLE	–	CRQ-dyspnea√ (both groups)-7w Non-inferior	–	ESWT (both groups)√ Non-inferior	–	CRQ-emotion (within group√ Non-inferior)	– .
P. de Roos/2016/ Holland	√	. –	√	–	–	–	Center: Medical care		–	–	I PA: (26.1min/d, 95%CI 7.3–44.9); 6MWD: ($P < 0.01$)	–	–	–
Wangxin/2013/ China	–	–	√	–	–	NIPPV	–	Drug	I SGRQ (t = 11.724, $P < 0.05$)	I Brog (t = 13.665, $P < 0.05$)	I 6MWD (t = 6.787, $P < 0.05$)	–	–	–

(*continued*)

Author/year/country	Intervention						Control		Outcome					
	EDU	BE	LLE	ULE	Aerobic/ Resistance exercise	Add-on	Our patient or hospital	Home	HRQOL	Dyspnea	Physical activity */Exercise capacity*	PF	Anxiety/ Depression	Others
Cristiane O Pradella/2015/ Brazil	–	– .	√	√	–	–	–	No intervention	Decreased by >4 units in all SGRQ domains√ no difference in C group.	–	6MWT (65.7 ± 83.1m vs 5.5 ± 92.9 m, $P < 0.05$) The endurance test (316.6 ± 81.8 m vs 31.2 ± 419.7 m, $P < 0.05$)	–	–	–
Júlio C/2010/Italy	√	–	√	√	–	–	–	No PR	–	BODE:√(H\O) no difference between the outpatient and at-home groups ($P = 0.90$)	6MWT √(H\O) no difference between the outpatient and at-home groups ($P = 0.44$) The control group no change	–	–	
Anne E Holland/2016/ Australia	√	–	√	√	√**(aerobic)**	–	Edu+LLE +ULE	–	No difference between groups	–	6MWD (No difference between groups)	–	–	–
François Maltais/2008 /America	√	–	–	–	√**(aerobic)**	–	√	–	CRQ: SGRQ: All similar efficacy	–	6MWT: 95%CI Similar efficacy	Lung function remains stable.	–	–
Carol McFarland/2012/ America	√	–	–	–	√**(aerobic)**	–	–	EDU+function strength training	CRQ ($P < 0.05$)√ A=B Especially in dyspnea	–	Only group A had a clinically significant improvement in walking distance	–	GDS ($P < 0.05$) √(both A and B)	–

Table 2. Outcomes of home-based intervention of included studies.

3.7.5. Breathing exercise, lower limb exercise, and upper limb exercise programs

Six of the RCTs reported outcome of BE, LLE, and ULE as home-based PR.[16,19,24,26,30,32] Comparing with hospital training, one trial showed that the standardized home-based program provides benefits in dyspnea.[22] Five of the trials reported that this intervention provides evidence that home-based PR improves the quality of life, breathing difficulties in daily life, and exercise ability in patients with severe and very serious COPD. It is important to note that patients who are far away from the hospital can be treated using home-based PR as part of the treatment.[19,24,26,30,32] Among those using BE, LLE, and ULE as home-based PR, one trial reported that the low-intensity HBPR that is fed back with the pedometer is an effective method to improve the PA, where the improvement of the physiological factors is related to the increased walking time of the COPD patient. At the same time, another trial reported that in subjects with severe COPD, a home-based NMES as an addition to PR does not lead to further improvement and may cause a burden to some patients (Table 2).

3.7.6. Aerobic exercise program

Three of RCTs reports the outcomes of aerobic exercise. One pilot study suggested that aerobic exercise and functional intensity training in home PR can improve the quality of life of patients with COPD to some extent.[29] Two of studies suggested that as a means of home-based PR, the short-term clinical outcome produced by the aerobic exercise with minimal resources can be equivalent to the outcome of the central PR[15,21] (Table 2).

4. Discussions

Home-based PR is to point to the place that executes PR as a family, because helping a patient to reduce economic costs and save time makes it more feasible. This systematic review of 21 studies is the first to investigate the effect of different home-based exercise trainings on COPD. Some articles show that home-based PR can improve HRQOL, exercise endurance of COPD patients, alleviate breathing difficulties in patients needing PR and bronchodilation, and attenuate the severity of their pulmonary condition. Fatigue and emotional states can also have advantage from home-based pulmonary rehabilitation when patients are unable to receive hospital PR.[13,14,24,26,30,32]

In this review, we found that daily, simple, structured, self-monitoring, family-based exercise training was an effective, low-cost intervention for the home-based PR program. This is also consistent with some research findings. Previous studies and guidelines have shown that PR is useful to patients with COPD because it can improve motor ability, muscle strength, symptoms, and HRQOL.[34] Home-based PR is also increasingly being recognized. This review further confirmed the effectiveness of home-based PR in HRQOL, PA, dyspnea, AF, etc. and further studied the effects of all kinds of home-based PR.

The present study has shown the effectiveness of simple, low-cost, low-intensity, home-based PR program that is suitable for causing the actual conditions capable of leading to an improvement in exercise capacity, relief for breathlessness, activities of daily living, and quality of life in patients with COPD. The use of minimal resources in the home-based PR program might result in a clinical outcome equivalent to a center-based PR. Home-based low-intensity aerobic training may sometimes be no less than outpatient or central intervention to improve dyspnea, health, and exercise tolerance. This is consistent with some previous studies.[35] Although high-intensity training in COPD patients has greater biological benefits than low-intensity training, studies have also shown that low-intensity training can also produce clinical benefits.

LLE training may be the best method of home-based exercise rehabilitation. Whether the primary method of home-based PR is simply LLE or LLE combined breathing training or LLE combined ULE, it can be confidently asserted that LLE training is the most appropriate method of delivering PR. This is consistent with the view in the guidelines for PR, it is stated that LLE training is a key core of PR.[34] At the same time, it is pointed out in the guide that the recommended evidence for lower limb training is Level A. This shows the importance of LLE training; in addition, LLE training can improve the patient's exercise endurance and is more convenient to carry out at home. Most of the sports indicated that training for home-based PR mainly consists of lower limb training, such as street walking daily, going up and down stairs, riding a bicycle, etc. and these also achieved better results.[14,17,22,23] Combined exercise training may be better than single exercise training. This indicates that the combined training program is superior to the LLE training alone.[16,24,30] Compared with single exercise training, many evidences show that the home-based PR of combined LLE training with breathing training and ULE shows great improvement in HRQOL, dyspnea, physical activity, and lung function.

Adverse events during home-based PR exercise were no more frequent than those in hospital or central nursing, which may be related to better supervision, effective control of exercise intensity, and remote

help and follow-up. It is suggested that more objective scientific indicators should be used to control the intensity, frequency, and duration of exercise training to ensure the safety of patients and achieve corresponding results. Under the right conditions, the use of additional measures may have better effects or better compliance, such as music, pedometer, and the use of NIPPV for severe patients.[13,14,18] This additional factor needs careful study and consideration. Otherwise, it may also be a burden for some patients.[32]

However, further studies are required. In this review, the sample size of some RCT articles is insufficient. At the same time, the intervention time of home-based PR is a major variable, and it has an important influence on the results of the study. Due to the difference in the intervention time, some indicators cannot be combined, but the improvement will be more pronounced as the intervention continues.

5. Conclusions

The results from the analysis may imply that simple, low-cost, low-intensity home-based PR program is suitable for the actual conditions that might lead to improvement in exercise capacity, relief for breathlessness, activities of daily living, and quality of life in patients with COPD. In particular, LLE training in home-based PR is more significant. At the same time, the combination of LLE training with breathing training and ULE training is more obvious than the simple LLE training. In addition, home-based low-intensity aerobic training may sometimes not be inferior to the outpatient or center intervention to improve dyspnea, health status, and exercise tolerance.

In conclusion, the simple and easy home-based PR exercise program is effective. Long-term home-based PR may require better maintenance strategies, which can benefit patients in the long run.

Ethical approval

Ethical issues are not involved in this paper.

Conflicts of interest

All contributing authors declare that no conflicts of interest exist.

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