INT J TUBERC LUNG DIS 24(10):991–999

http://dx.doi.org/10.5588/ijtld.19.0526

Evidence for pulmonary rehabilitation in chronic respiratory diseases in sub-Saharan Africa: a systematic review

F. M. Bickton,[1] C. Fombe,[2] E. Chisati,[3] J. Rylance[1,4]

[1]Malawi-Liverpool-Wellcome Trust Clinical Research Programme, Blantyre, [2]Physiotherapy Department, Queen Elizabeth Central Hospital, Blantyre, [3]Physiotherapy Department, College of Medicine, Blantyre, Malawi; [4]Department of Clinical Sciences, Liverpool School of Tropical Medicine, Liverpool, UK

SUMMARY

BACKGROUND: Pulmonary rehabilitation (PR) is a highly effective non-pharmacological treatment for patients with chronic respiratory diseases.

OBJECTIVE: To synthesise the evidence for PR practice and efficacy in sub-Saharan Africa.

METHODS: We searched in PubMed and Scopus for relevant studies and scanned reference lists of relevant studies from these databases for additional studies. Articles meeting the inclusion criteria were included. Pre-determined data were extracted independently by two reviewers. A narrative synthesis approach was used in the interpretation of findings.

RESULTS: Six studies were included, totalling 275 participants. Indications for PR were chronic obstructive pulmonary disease, asthma, pulmonary tuberculosis and post-tuberculosis lung disease. Programmes ran for 6–12 weeks, universally incorporated exercise, and variously used home-based and hospital-based delivery models. All were interventional studies, of which two were randomised controlled trials, and primarily reported pulmonary function and exercise tolerance endpoints. Evidence for individualising the exercise regimen was available in three studies.

CONCLUSIONS: There is limited evidence on PR design and efficacy in sub-Saharan Africa, but available data support its use in a variety of chronic respiratory conditions. Future studies should report core outcome sets and their individualised exercise and education regimens.

KEY WORDS: pulmonary rehabilitation; chronic respiratory diseases; sub-Saharan Africa; systematic review

CHRONIC RESPIRATORY DISEASES (CRDs) are a major and increasingly important global health issue; chronic obstructive pulmonary disease (COPD) and asthma are the most common among these,[1] with combined annual death rates of approximately 3.15 million.[2,3] COPD is increasing in incidence, with age-standardised mortality being highest in low- and middle-income countries (LMICs), particularly South Asia and sub-Saharan Africa (SSA).[4,5] Known risk factors for CRDs include smoking, outdoor air pollution, household smoke exposure, occupational dust exposure, ozone and secondhand smoke.[6] Pulmonary tuberculosis (PTB) can also lead to irreversible lung damage which is most frequently radiologically apparent as bronchiectasis, fibrosis and cavitation.[6,7] Progressive loss of lung function is associated with long-term respiratory symptoms and clinical presentation as CRDs, including COPD, bronchiectasis and aspergillosis.[6] These conditions can jointly be referred to as post-TB chronic lung disorders (p-TBLD).[8] As TB remains one of the top 10 causes of mortality worldwide, with an estimated 10.4 million new cases and 1.3 million deaths in 2016, the problem of p-TBLD is likely to be substantial but is poorly measured.[6]

CRDs can lead to significant chronic morbidity and loss of economic productivity, which burden patients, families and health systems alike. For conditions such as COPD, pharmacotherapy such as bronchodilators is currently the mainstay of the treatment. However, none of the drugs currently available for COPD can reduce the progressive decline in lung function which is the hallmark of this disease.[9] In addition, drugs for CRDs can be less available and affordable, especially in low-income settings, including SSA, where the availability and affordability of medicines and diagnostics recommended for the management of asthma and COPD is a big challenge.[10]

Fortunately, the rational use of pharmacotherapy for CRDs could be complemented by non-pharmacological treatments. For COPD, pulmonary rehabilitation (PR) is well established as a highly effective intervention that improves symptoms, quality of life and survival[11], and a recent trial has shown a

Correspondence to: Fanuel Meckson Bickton, Lung Health Research Group, Malawi-Liverpool-Wellcome Trust Clinical Research Programme, PO Box 30096, Chichiri, Blantyre 3, Malawi. e-mail: fbickton@mlw.mw; fmbickton@stud.medcol.mw

Article submitted 12 August 2019. Final version accepted 2 January 2020.

substantial reduction in the risk of readmission in patients who undertake PR immediately after admissions for COPD.[12] Recent evidence also supports PR for other CRDs, including p-TBLD, asthma, and interstitial (fibrotic) lung disease (ILD).[13] In addition, while there is still a cost in providing it, PR is relatively more cost-effective than the pharmacotherapy for CRDs, as it may be delivered using existing local staff with minimal equipment. It would thus require little investment and be sustainable and scalable in resource-limited settings such as SSA.[14]

PR is a comprehensive package of interventions, which can include exercise training, education and behaviour management.[15] Exercise training is a core component which should be prioritised;[16] however, this may require the modification of traditional training paradigms, and the need to take into consideration patient strength and endurance.[17] It has been suggested that PR is now sufficiently understood to obviate further randomized trials in high-income countries (HICs).[18] However, given that the design and delivery of PR programmes need to be individualised to patient groups and context,[19] high-quality data are needed outside HICs.

While the need for PR in SSA is clear, there is currently no systematic review that has investigated the research evidence for its practice and effectiveness in the region. This study is aimed to close this research gap. Using the PICOS (participants, interventions, comparisons, outcomes and study design) approach, we systemically reviewed randomised controlled trials (RCTs) and non-RCTs to answer the following questions: 1) In which CRDs has PR been tested in SSA? 2) What designs and modes of delivery have been used in PR programmes tested in people with CRDs in SSA? 3) What is the evidence for individualising the exercise regimens of the PR programmes tested in people with CRDs in SSA? 4) What is the effectiveness of PR in people with CRDs in SSA?

METHODS

A protocol for this review was registered in the International Prospective Register of Ongoing Systematic Reviews (PROSPERO)[20] on 1 July 2019 (registration number: CRD42019128929). The conduct and reporting of the review were guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Protocol (PRISMA-P).[21,22] Ethics approval was not required, as only publicly available data were used.

Study eligibility criteria and identification

JR and FB independently determined eligibility, and discrepancies were resolved by consensus. With reference to the same PICOS approach that informed our review questions, our eligibility criteria were as follows: participants with CRDs, attending a PR programme. The comparison or control domain was not necessary since additional RCTs comparing PR and conventional care in CRDs are not warranted as there is now enough evidence on the superiority of PR.[18] We therefore included both RCTs and non-RCTs. In the absence of standardised PR core outcomes, we captured the broadest range of outcomes possible, including symptoms, functional limitations, spirometry, and quality of life.

We selected peer-reviewed articles of studies conducted within SSA between 1997 and 2019. The start year (1997) was chosen to coincide with the publication of the first Pulmonary Rehabilitation Evidence-Based Guidelines.[23] Articles must have been accessible in full text in English (or available translation) and describe a study on PR for a defined respiratory disease or syndrome. The searches were performed in April 2019, using keywords and MeSH terms in PubMed and Scopus (see Supplementary Table S1 for search terms used in PubMed); reference lists were also scanned for relevant secondary references.

Data extraction, synthesis and analysis

Data were independently extracted by two reviewers (FB and CF) using a data extraction form which was based on our pre-review of identified manuscripts, with consensus-resolution of disagreement. The following data were sought and either coded or maintained in narrative form: study characteristics (country, year of publication and design), participant characteristics (sample size, condition and mean age), intervention characteristics (setting of delivery, duration of session and programme, frequency, components, team composition and evidence for individualising the exercise regimen), endpoints (primary and secondary) and summary measures of effect. We extracted all reported outcomes and synthesised and analysed the extracted data using a narrative description and tabular summary of key characteristics of the studies.

Assessment of reporting and methodological quality

We employed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) checklist,[24] and assessed potential for bias using the Newcastle–Ottawa Scale (NOS)[25] for non-randomised cohort studies. For randomised controlled studies, we employed the 2017 Consolidated Standards of Reporting Trials (CONSORT) checklist of information to include when reporting a RCT assessing non-pharmacological treatments (NPTs)[26] (for 2-arm parallel-group trials) and a CONSORT checklist for the reporting of multi-arm parallel-group RCTs.[27] For methodological quality, we incorporated a revised Cochrane risk-of-bias tool

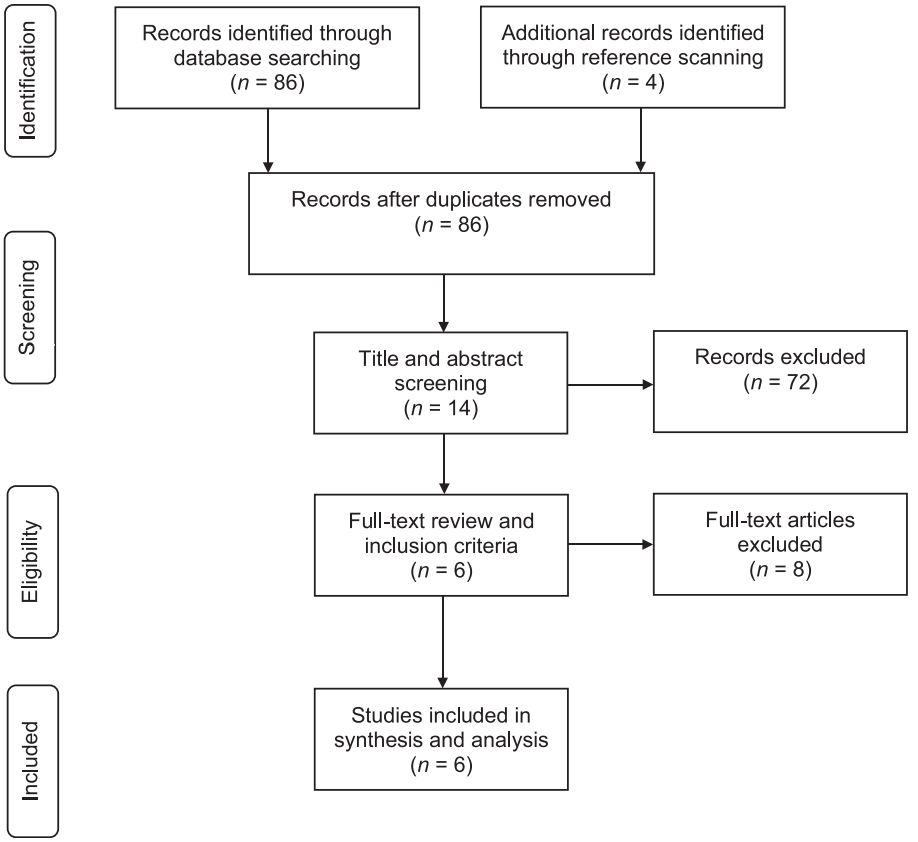

Figure Flow chart of the study selection, adapted from the 2009 PRISMA Group flow diagram. PRISMA = Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

for RCTs (RoB 2)[28,29] in tandem with the CONSORT checklist.

RESULTS

Study selection

Literature search terms identified 86 articles, of which six met the inclusion criteria (Figure). We excluded 72 non-relevant articles during title and abstract review. Of the remaining 14 articles, we further excluded one duplicate,[30] one with abstract only and no author contact details,[31] one non-research guideline[32] and five that did not meet inclusion criteria.[33–37]

Study characteristics

Of the six finally included, three studies were conducted in South Africa,[38–40] two in Uganda[41,42] and one in Nigeria,[43] and all were published between 2010 and 2018. The studies were focused on the feasibility and acceptability of PR programmes. All 6 were experimental or intervention studies, with 2 being RCTs and 4 being pre-post (before-and-after) non-RCTs (Table).

Participant characteristics

A total of 275 participants were represented, all aged ≥18 years. Of these, COPD was the indication for inclusion in 59 participants across three studies.[38,42,43] A further 88 participants had asthma within a single study,[40] 61 participants had p-TBLD in the two Uganda studies[41,42] and 67 participants were included in a separate study on PTB during antituberculous treatment[39] (Table).

Interventions

The PR programmes used were based either in referral-level hospitals ($n = 3$) or at participants' homes ($n = 3$). Their durations ranged from 6 to 12 weeks, with variations in composition as follows: exercise, education, nutrition, self-management activities and psychosocial support. The staff who delivered and supervised the programmes were variously composed across the studies, with at least a physiotherapist being present in all programmes to deliver and supervise the exercise training component. The other components of the programmes, such as education, were delivered and supervised by various professionals, including physicians, nurses, physiotherapists, counsellor, home-based caregivers, students (medical, physiotherapy and nutrition), assistant researchers (with unspecified expertise or profession) or a qualified practitioner in exercise

Table Study characteristics and extracted data

Study, country, year, reference	Design	IIntervention	Endpoints	Results summary*
Clarke, South Africa, 2016[38]	Pre-post, single-arm, non-RCT: COPD patients ($n = 7$); age range 31–71 years (mean: 57)	Setting: home-based; Timing: 12 weeks' duration; Content: exercise, nutrition and education; Staff: supervised, home-based caregiver, medical student, physiotherapy student and human nutrition student; Text evidence for individualisation: absent	Primary: Δ pulmonary function; Δ 6MWTD; Δ QoL; Δ BODE index Secondary: Δ health literacy (inhaler technique and disease-specific insight)	• No significant improvement in FEV_1%, 6MWTD or BODE index at Week 6; • Improved QoL score in symptom score component only at Week 6 ($P = 0.03$); • Improved FEV_1% by mean 8% at Week 12†; • Improved QoL score at Week 12; • Non-significant increase in 6MWTD at Week 12; • Non-significant change in BODE index at Week 12; • Inappropriate inhaler technique in 5/7 patients at baseline, 3/7 at Week 6 and 2 at Week 12; • No knowledge of COPD in 5 patients at baseline and inadequate knowledge in 2 patients; • Adequate COPD knowledge in 5 patients at Week 12; • Inadequate COPD knowledge in 2 patients at Week 12
Jones, Uganda, 2017[41]	Pre-post, single arm, mixed-methods, non-RCT: post-TBLD patients ($n = 29$); mean age: 45 years	Setting: hospital-based; Timing: 6 weeks' duration, ~2h/session; Content: exercise and education; Staff: physiotherapist, doctor, specialist nurse and counsellor; Text evidence for individualisation: available	Primary: Δ health status (CCQ); Δ exercise tolerance Secondary: Δ pulmonary function; biometrics; Δ chest pain; Δ haemoptysis; Δ cough; participation and completion level	• 0.95 mean improvement in CCQ; health status (CCQ) scores exceeded MCID of –0.4 post-PR; • 90 m (MCID 48 m) mean improvement in ISWT 2.5 sec improvement in STST time, also beyond MCID (MCID 2.3 sec); • Individual-level improvements in ISWT level in 59% of patients and 61% of patients in STST and 61% of patients above MCIDs; • High level of participation and completion at 85%
de Grass, South Africa, 2014[39]	Pre-post, RCT (2-arm): PTB patients ($n = 67$): Intervention Group ($n = 34$), Control Group ($n = 33$); 18–65 years	Setting: home-based; Timing: 6 weeks' duration; Content: exercise, self-management activities and education; Staff: assistant researcher (expertise not specified) and physiotherapist; Text evidence for individualisation: absent	Primary: Δ pulmonary function; Δ exercise tolerance; Δ HRQoL Secondary: Δ modified Borg Scale	• No significant differences in Week 6 in FEV_1 ($P = 0.1$; 95% CI: –0.07 to 0.51) and FVC ($P = 0.2$; 95% CI: –0.9 to 0.51); • Significant differences in both values for FVC ($P = 0.004$; 95% CI: –0.36 to -0.07) and FEV_1 ($P = 0.001$; 95% CI: –0.33 to -0.08) following intragroup analysis of baseline vs. Week 6; • Significant difference in distance in the Intervention Group at Week 6 ($P = 0.007$; 95% CI: 15.37 to 92.7); • Significant difference in modified Borg Scale at Week 6 ($P = 0.03$); • No significant differences in exercise tolerance at Week 6 after adjusted analysis ($P > 0.05$); • No significant difference in HRQoL over 6-week period ($P = 0.789$)
Jones, Uganda, 2018[42]	Pre-post, single-arm, qualitative (non-RCT): post-TBLD ($n = 32$), COPD patients ($n = 10$)	Setting: hospital-based; Timing: 6 weeks duration, x2/week, 2h/session; Content: exercise and education; Staff: physio, doctor, specialist nurse and counsellor; Text evidence for individualisation: available	Primary: Δ experiences of CRD post-PR Secondary: participant recommendations to improve PR	• Experiences of a complex array of interacting problems (e.g., physical, social, psychological, economic) pre-PR; • Positive Δ in experiences above post-PR
Ige, Nigeria, 2010[43]	Pre-post, single-arm non-RCT: COPD ($n = 42$; mean age: 66 years	Setting: hospital-based; Timing: 6 weeks' duration, x2/week, 2h a session; Content: exercise, education and psychosocial support; Staff: nurse educator, physio, respiratory physician; Text evidence for individualisation: absent	Δ pulmonary function; Δ exercise tolerance; Δ SaO_2; Δ breathlessness; Δ resting cardiogram; Δ condition-specific measure; Δ psychological distress measure; Δ QoL measure; Δ HRQoL; Δ anxiety and depression; Δ SIP	• No significant Δ pulmonary function: mean FEV_1 (L) was 0.74 ± SD 0.34 at 3 months and 0.70 ± SD 0.26 at 6 months; mean VC (L) was 1.99 ± SD 0.66 at 3 months and 1.92 ± SD 0.64 at 6 months; mean PEFR (L/min) was 142.6 ± SD 51.4 at 3 months and 137.9 ± SD 40.2 at 6 months; • No Δ SaO_2 and breathlessness: mean SaO_2 90.46 ± SD 5.4 at 3 months and 90.29 ± SD 5.4 at 6 months; • Significant Δ in ISWTD (in m): mean 182.6 ± SD 104 at 3 months and 193.9 ± SD 103 at 6 months; 95% CI: 11 to 39; $P < 0.001$; • Significant improvement at 3 months in HRQoL as measured on the CRDQ and, apart from dyspnoea, improvements were maintained at 6 months), i.e., mean difference ($P < 0.05$) from baseline for dyspnoea was 1.9 (95%CI: 0.5 to 3.5) at 3 months and 1.7 (95%CI: –0.2 to 3.5) at 6 months; mean difference ($P < 0.05$) from baseline for fatigue was 2.7 (95%CI: 1.5 to 4.1) at 3 months and 1.6 (95%CI: 0.03 to 3.2) at 6 months; mean difference ($P < 0.05$) from baseline for emotion was 3.2 (95%CI: 1.8 to 4.6) at 3 months and 2.5 (95%CI: 0.2 to 4.8) at 6 months; and mean difference ($P < 0.05$) from baseline for mastery was 2.0 (95%CI: 0.7 to 3.3) at 3 months and 2.8 (95%CI: 1.3 to 4.2) at 6 months; • No significant Δ in SIP at 3 months (mean difference from baseline +0.5 (95%CI: –1.9 to 2.8), but significant at 6 months (mean difference from baseline –1.5(95%CI: –3.3 to 0.3); • Significant reduction in both the anxiety and depression sub-scale scores as measured on the HAD (mean difference from baseline for anxiety was –0.7 (95%CI: –0.04 to –1.4) at 3 months and –0.8 (95%CI: –0.2 to 1.8) at 6 months; mean difference from baseline for depression was –0.5 (95%CI: –0.2 to 1.2) at 3 months and –0.69 (95%CI: –0.1 to 1.4) at 6 months

Table (*continued*)

Study, country, year, reference	Design	Intervention	Endpoints	Results summary*
Shaw, South Africa, 2011[40]	Pre-post, 4-arms RCT comparing aerobic exercise, no exercise, diaphragmatic inspiratory resistive breathing (DR), and aerobic exercise combined with DR: asthmatics (moderate-persistent) ($n = 88$); 18–34 years	Setting: home-based; Timing: 8 weeks' duration, x3/week; Content: exercise; Staff: qualified practitioner in exercise therapy and rehabilitation; Text evidence for individualisation: available	Primary: Δ pulmonary function; Δ abdominal and thoracic dimensions and kinematics Secondary: level of compliance/adherence to exercise programmes	Significant and superior improvements in pulmonary function and abdominal and thoracic kinematics with CE at Week 8: • FVC ($P < 0.001$), FEV_1 ($P < 0.001$), FEV_1/FVC ($P = 0.031$), PEF ($P = 0.001$), MVV ($P = 0.001$), and IVC ($P < 0.001$) changed significantly from baseline: mean FVC was 2.87 ± SD 0.67 at Week 0 and 3.68 ± SD 0.82 at Week 8; mean FEV_1 was 2.70 ± SD 0.67 at Week 0 and 3.30 ± 0.70 at Week 8; mean FEV_1/FVC ratio was 93.82 ± SD 5.47 at Week 0 and 91.23 ± SD 5.74 at Week 8; mean PEF was 7.14 ± SD 2.22 at Week 0 and 7.99 ± SD 2.22 at Week 8; mean MVV was 99.90 ± SD 41.79 at Week 0 and 119.01 ± SD 43.9 at Week 8; and mean IVC was 3.26 ± SD 0.97 at Week 0 and 3.78 ± SD 0.9 at Week 8; • No significant improvements in FEF_{25}, FEF_{50}, FEF_{75}, $FEF_{25–75}$, V_E, F_b and V_T: mean FEF_{25} was 2.46 ± SD 1.09 at Week 0 and 2.29 ± SD 0.56 at Week 8; mean FEF_{50} was 4.21 ± SD 1.50 at Week 0 and 4.31 ± SD 1.0 at Week 8; mean FEF_{75} was 6.24 ± SD 1.87 at Week 0 and 6.61 ± SD 1.51 at Week 8; mean $FEF_{25–75}$ was 3.90 ± SD 1.44 at Week 0 and 3.88 ± SD 0.85 at Week 8; mean V_E was 14.38 ± SD 9.76 at Week 0 and 16.00 ± SD 11.82 at Week 8; mean F_b was 23.57 ± SD 8.18 at Week 0 and 26.08 ± SD 8.48 at Week 8; and mean V_T was 0.72 ± SD 0.48 at Week 0 and 0.75 ± SD 0.59 at Week 8; • Significant ($P \leq 0.05$) improvements were found in chest circumference (cm) during inspiration at the height of the second intercostal space following CE ($P < 0.001$): mean inspiratory circumference was 92.18 ± SD 6.38 at Week 0 and 94.76 ± SD 6.49 at Week 8; • No significant improvements in chest circumferences (cm) following CE during rest and expiration at the height of the second intercostal space: mean resting circumference was 87.52 ± SD 6.36 at Week 0 and 87.47 ± SD 6.3 at Week 8; mean expiratory circumference was 86.21 ± SD 6.96 at Week 0 and 86.04 ± SD 6.95 at Week 8; • Significant improvements, following CE, in chest circumferences (cm) during inspiration ($P < 0.001$), expiration ($P = 0.002$) and rest ($P = 0.023$) at the height of the xiphoid process: mean inspiratory circumference was 84.30 ± SD 6.66 at Week 0 and 87.48 ± SD 6.88 at Week 8; mean expiratory circumference was 79.06 ± SD 7.06 at Week 0 and 77.82 ± SD 7.57 at Week 8; and mean resting circumference was 80.18 ± SD 6.55 at Week 0 and 79.07 ± SD 7.03 at Week 8; • Significant improvement in abdominal circumference (cm), following CE, during inspiration ($P < 0.001$) and expiration ($P < 0.001$) at the height of the midpoint between the xiphoid process and umbilicus: mean inspiratory circumference was 75.42 ± SD 8.49 at Week 0 and 78.40 ± SD 8.90 at Week 8; mean expiratory circumference was 72.54 ± SD 8.58 at Week 0 and 69.65 ± SD 8.29 at Week 8; • No significant improvement, following CE, in the resting circumferences (cm) at the height of the midpoint between the xiphoid process and umbilicus: mean resting circumference was 74.23 ± SD 7.95 at Week 0 and 73.60 ± SD 8.56 at Week 8

* In de Grass et al.'s study, no data on measures of central tendency and variability were available for results summaries 1–6, while in Clarke et al.'s study, no data on measures of central tendency and variability were available for results summaries 1, 2, 5 and 6. Moreover, in Clarke et al.'s study, there were no explicit data on whether the improvements reported in results summaries 2, 3 and 4 were statistically significant or not.
† One patient developed claudication symptoms in the course of the 3-month intervention and had deterioration in walking distance while respiratory parameters improved.
RCT = randomised controlled trial; COPD = chronic obstructive pulmonary disease; Δ(S) = change(s); 6MWTD = 6-minute walk test distance; QoL = quality of life; BODE = body-mass index, airflow obstruction, dyspnea, and exercise; FEV_1 = forced expiratory volume in one second; TBLD = tuberculosis lung disease; CCQ = clinical COPD questionnaire; MCID = minimal clinically important difference; PR = pulmonary rehabilitation; ISWT = incremental shuttle walk test; STST = sit-to-stand test; PTB = pulmonary tuberculosis; HRQoL = health-related quality of life; CI = confidence interval; FVC = forced vital capacity; CRD = chronic respiratory disease; SaO2 = oxygen saturation; SIP = sickness impact profile; SD = standard deviation; PEFR = peak expiratory flow rate; CRDQ = chronic respiratory disease questionnaire; HAD = hospital anxiety and depression scale; CE = combined aerobic exercise and diaphragmatic breathing; MVV = maximal voluntary ventilation; IVC = inspiratory vital capacity; FEF = forced expiratory flow; FEF_{25} = FEF at 25% of FVC; FEF_{50} = FEF at 50% of FVC; FEF_{75} = FEF at 75% of FVC; $FEF_{25–75}$ = FEF between 25–75% of FVC; V_E = minute ventilation; F_B = breathing frequency; V_T = tidal volume.

therapy and rehabilitation. More detailed information about each study is shown in the Table.

Methodological quality

A standard NOS criterion for what constitutes a high-quality study has not yet been universally established, but we considered scores ≥ 7 to reflect high quality.[44] Based on this criterion, all four non-RCTs were found to be at high risk of bias (score ≤ 5). The issues included inadequate and/or lack of information on the three domains (selection, comparability, and outcome) on which quality assessment was based. Inadequate and/or lack of information in important areas were also an issue in the RCTs. Detailed results from the methodological quality assessment of all studies are given in Supplementary Table S2.

Exercise individualisation and education

Evidence for individualising the exercise regimens of PR programmes was available in three studies,[40–42] including the evidence for progression of exercise training loads. For example:

> The exercise regime was individually prescribed, monitored, and increased as the programme progressed...[41]

> The intervention was performed in groups, but the exercise training was individually prescribed and intensified as the programme progressed.[42]

> Individual age predicted maximum heart rate (HR_{max}) was utilised... to develop a suitable programme for all subjects without the need for expensive equipment...[40]

The remaining three studies had no explicit evidence of regimen individualisation. Details on other programme components, including education and self-management aspects, were very limited (either completely missing or inadequate).

Effectiveness

The Table shows the effects of PR programmes. Multiple primary outcomes were the norm in all the studies reviewed, some of which were inconsistently used, which led to the reporting various results, including physical, economic, and psychosocial effects, and self-esteem, health literacy, exercise tolerance, pulmonary function and quality of life. Pulmonary function and exercise tolerance effects were predominantly assessed and reported. Forced expiratory volume in 1 sec (FEV_1) and forced expiratory volume (FVC) were common outcome measures for pulmonary function, while the 6-min walk test (6MWT) and the incremental shuttle walk test (ISWT) were used as outcome measures for exercise tolerance. Pulmonary function was reported in 5 studies,[38–41,43] of which 3 (including the 2 RCTs[37,38]) demonstrated improvement after the programme,[38–40] 1 suggested a non-significant but potentially clinically important increase,[41] and 1 showed no significant change.[43] Exercise tolerance was reported in 4 studies,[38,39,41,43] of which 1 reported significant improvement,[43] 1 reported a non-significant but potentially clinically important increase,[41] and 2 showed no significant change[38,39] (including an RCT[39]). Dyspnoea, as the most frequently reported symptom in CRD,[45] was assessed in four studies.[38,39,41,43] Of these, 2 reported significant improvements (including an RCT[39]),[38,39] 1 reported a non-significant but potentially clinically important difference,[41] and 1 showed no significant change.[43]

DISCUSSION

We found evidence of clinically significant improvements in symptoms and lung function in patients receiving PR for various CRDs in SSA. However, data were limited and only three countries were represented. Studies predominantly examined participants with COPD (three out of the six studies). While the evidence base for PR outside of Africa is dominated by this patient group, recent evidence suggests that similar benefits could be gained in other CRDs, including interstitial lung disease, bronchiectasis, asthma, cystic fibrosis, lung transplantation, lung cancer and pulmonary hypertension.[15,46,47] For example, a new study has shown that patients with bronchiectasis benefit from PR to broadly the same extent as patients with COPD.[48] PR is also clearly indicated in the management of patients with p-TBLD,[15,49] which is infrequently found in high-income countries, but extremely common in TB-endemic regions,[6] particularly LMICs.[50] It is reported that, in these settings, TB increases the odds of p-TBLD by more than threefold on average.[6]

PR can be home- or hospital-/centre-based;[11] each was equally represented in this systematic review. Although it is recognised that hospital-/centre-based programmes are a standard mode of PR delivery,[51] both modes were effective in various study outcomes of interest in this systematic review. In a multicentre RCT,[52] home-based PR was found to be a useful, equivalent alternative to hospital-based PR in patients with COPD. In addition, another recent study, which aimed to compare the cost-effectiveness and cost-utility of home and centre-based PR for adults with stable COPD, concluded that home-based PR provided a cost-effective alternative model for people with COPD who cannot access traditional centre-based programmes.[53] However, to date, home-based PR has still not been widely adopted into clinical practice, possibly because a sound economic model has not been developed.[17]

In line with recommendations,[54] each PR pro-

gramme ran for at least 6 weeks and focussed on exercise training, which seems reasonable, as exercise is a component with the strongest level of evidence for benefit.[16] However, the health gains attributable to a broader package are important and may be underrepresented in the existing African literature. In addition, to optimise the physical and physiological benefits, it is necessary to individualise exercise training for each patient, including exercise intensity.[55] In this systematic review, there was no evidence for individualising the PR exercise regimens in three studies, which made it difficult to assess the quality of these programmes. Moreover, the issues of methodological quality may limit the validity of the study results when using these as a basis for recommending PR with absolute certainty in the management of CRDs in SSA.

There was variable reporting of outcomes of interest, of which pulmonary function and exercise tolerance indices predominated. Studies in our review noted improvements in lung function which might not be typical of the broader literature. This raises the possibility that, perhaps due to limited access to pharmacological therapy, patients in SSA may benefit differently from those for whom prior pharmacotherapy was optimal. We note that the choice of reported metrics was also variable, leading to heterogeneity, which limits the potential for meta-analysis or a broader assessment.[56,57] Our review would support the suggestion of a consistently implemented "core outcome set".[58,59] This could reduce outcome reporting bias and broaden the relevance to different stakeholders, including patients, healthcare workers and those overseeing the wider healthcare system.[60] In this systematic review, both exercise tolerance and dyspnoea were outcomes in four of six studies;[38,39,41,43] these are well-recognised and stakeholder-valued positive PR outcomes in other settings.[61] Selection of core outcomes should include reaching a consensus on the key measures which best represent them.

Our systematic review used a broad search strategy to identify relevant evidence for PR in SSA and rigorous implementation of PRISMA guidelines. However, only studies published in English were included. This may have limited our sample, but we found no examples of this during article screening. The small number of studies, their heterogeneity and the lack of consistent outcome variables did not allow meta-analysis.

CONCLUSIONS

Despite limitations, all the included studies in this review suggest that extending PR programmes in SSA could be beneficial to patients. Efforts should be made to individualise the exercise regimens of PR programmes in the region. Larger studies with high methodological quality that employ consistent outcome variables are warranted to allow careful meta-analysis of both effectiveness and cost-effectiveness.

Acknowledgements

The authors thank D Chiweza, the Librarian at the College of Medicine, University of Malawi, Blantyre, Malawi, for training the corresponding author in systematic review methods.

FMB receives research internship funding from the Malawi-Liverpool-Wellcome Trust Clinical Research Programme.

Conflicts of interest: none declared.

References

1 India State-Level Disease Burden Initiative CRD Collaborators. The burden of chronic respiratory diseases and their heterogeneity across the states of India: The Global Burden of Disease Study 1990–2016. Lancet Glob Health 2018; 6(12): e1363–e1374.
2 López-Campos J L, Tan W, Soriano J B. Unravelling the many faces of COPD to optimize its care and outcomes. Respirology 2016; 21(1): 14–23.
3 World Health Organization. Global surveillance, prevention and control of chronic respiratory diseases: a comprehensive approach. Geneva, Switzerland: WHO, 2007. https: //www.who.int/gard/publications/GARD%20Book%202007.pdf
4 Ahmed R, Robinson R, Mortimer K. The epidemiology of noncommunicable respiratory disease in sub-Saharan Africa, the Middle East, and North Africa. Malawi Med J 2017; 29(2): 203–211.
5 Burney P, Jarvis D, Perez-Padilla R. The global burden of chronic respiratory disease in adults. Int J Tuberc Lung Dis 2015; 19(1): 10–20.
6 van Kampen S C, Wanner A, Edwards M, Harries A D, Kirenga B J, Chakaya J, et al. International research and guidelines on post-tuberculosis chronic lung disorders: a systematic scoping review. BMJ Glob Health 2018; 3: e000745.
7 Amaral A F S, Coton S, Kato B, et al. Tuberculosis associates with both airflow obstruction and low lung function: BOLD results. Eur Respir J 2015; 46: 1104–1112.
8 World Health Organization. Global surveillance, prevention and control of chronic respiratory diseases: a comprehensive approach. Geneva, Switzerland: WHO, 2007.
9 Montuschi P. Pharmacological treatment of chronic obstructive pulmonary disease. Int J Chron Obstruct Pulmon Dis 2006; 1(4): 409–423.
10 Kibirige D, Sanya R E, Nantanda R, Worodria W, Kirenga B. Availability and affordability of medicines and diagnostic tests recommended for management of asthma and chronic obstructive pulmonary disease in sub-Saharan Africa: a systematic review. Allergy Asthma Clin Immunol 2019; 15: 14.
11 Corhay J-L, Dang D N, Cauwenberge H V, Louis R. Pulmonary rehabilitation and COPD: providing patients a good environment for optimizing therapy. Int J Chron Obstruct Pulmon Dis 2014; 9: 27–39.
12 Moore L, Hogg L, White P. Acceptability and feasibility of pulmonary rehabilitation for COPD: a community qualitative study. Prim Care Respir J 2012; 21(4): 419–424.
13 Alison J A, McKeough Z J, Johnston K, McNamara R J, Spencer L M, Jenkins S C, et al On behalf of the Lung Foundation Australia and the Thoracic Society of Australia and New Zealand. Australian and New Zealand Pulmonary Rehabilitation Guidelines. Respirology 2017; 22(4): 800–819.
14 Griffiths T L, Phillips C J, Davies S, Burr M L, Campbell I A. Cost effectiveness of an outpatient multidisciplinary pulmonary rehabilitation programme. Thorax 2001; 56(10): 779–784.
15 Spruit M A, Singh S J, Garvey C, ZuWallack R, Nici L, Rochester C, et al. An official American Thoracic Society/

European Respiratory Society statement: key concepts and advances in pulmonary rehabilitation. Am J Respir Crit Care Med 2013; 188(8): e13–e64.
16 Ries A L, Bauldoff G S, Carlin B W, Casaburi R, Emery C F, Mahler D A, et al. Pulmonary rehabilitation. Joint AACP/AACVPR evidence-based clinical practice guidelines. Chest 2007; 131(5 Suppl): 4S–42S.
17 Lee A, Holland A. Time to adapt exercise training regimens in pulmonary rehabilitation – a review of the literature. Int J Chron Obstruct Pulmon Dis 2014; 9(1): 1275–1288.
18 Lacasse Y, Cates C J, McCarthy B, Welsh E J. This Cochrane Review is closed: deciding what constitutes enough research and where next for pulmonary rehabilitation in COPD. Cochrane Database Syst Rev 2015; (11): ED000107.
19 Early F, Wellwood I, Kuhn I, Deaton C, Fuld J. Interventions to increase referral and uptake to pulmonary rehabilitation in people with COPD: a systematic review. Int J Chron Obstruct Pulmon Dis 2018; 13: 3571–3586.
20 Bickton F, Rylance J. Evidence for pulmonary rehabilitation (PR) in chronic respiratory diseases (CRDs) in sub-Saharan Africa (SSA): a systematic review. PROSPERO 2019 CRD42019128929. York, UK: York University, 2019. http://www.crd.york.ac.uk/PROSPERO/display_record.php?ID=CRD42019128929
21 Moher D, Shamseer L, Clarke M, Ghersi D, Liberati A, Petticrew M, et al. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. Syst Rev 2015; 4: 1.
22 Shamseer L, Moher D, Clarke M, Ghersi D, Liberati A, Petticrew M, et al. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015: elaboration and explanation. BMJ 2015; 349: g7647.
23 Ries A L. Pulmonary rehabilitation: summary of an evidence-based guideline. Respir Care 2008; 53(9): 1203–1207.
24 Vandenbroucke J P, von Elm E, Altman D G, Gøtzsche P C, Mulrow C D, Pocock S J, et al. Strengthening the Reporting of Observational Studies in Epidemiology (STROBE): explanation and elaboration. Int J Surg 2014; 12(12): 1500–1524.
25 Wells G A, Shea B, O'Connell D, Peterson J, Welch V, Losos M, Tugwell P. The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomised studies in meta-analyses. Ottawa, ON, Canada: Ottawa Hospital Research Institute, 2019. http://www.ohri.ca/programs/clinical_epidemiology/oxford.asp
26 Boutron I, Altman D G, Moher D, Schulz K F, Ravaud P, CONSORT NPT Group. CONSORT statement for randomized trials of nonpharmacologic treatments: a 2017 update and a CONSORT extension for nonpharmacologic trial abstracts. Ann Intern Med 2017; 167(1): 40–47.
27 Juszczak E, Altman D G, Hopewell S, Schulz K. Reporting of Multi-Arm Parallel-Group Randomized Trials Extension of the CONSORT 2010 Statement. JAMA 2019; 321(16): 1610–1620.
28 Cochrane. RoB 2: A revised Cochrane risk-of-bias tool for randomized trials. London, UK: Cochrane, 2011. https://methods.cochrane.org/bias/resources/rob-2-revised-cochrane-risk-bias-tool-randomized-trials
29 Higgins J P T, Savović J, Page M J, Sterne J A C (eds); on behalf of the ROB2 Development Group Revised Cochrane risk-of-bias tool for randomized trials (RoB 2). London, UK: Cochrane, 2019. https://drive.google.com/file/d/1pbkUAco17D0lVziiVeUTuvaBME7dACmD/view
30 Shaw I, Shaw B S, Brown G A. Role of diaphragmatic breathing and aerobic exercise in improving pulmonary function and maximal oxygen consumption in asthmatics. Sci Sports 2010; 25: 139–145.
31 Muzembo N, Nkakudulu B H, Frans A. Respiratory rehabilitation in patients with bronchial asthma and chronic obstructive pulmonary disease (COPD) in Kinshasa. Rev Pneumol Clin 2001; 57(3): 209–218.
32 Abdool-Gaffar M S, Ambaram A, Ainslie G M, et al. Guideline for the management of chronic obstructive pulmonary disease—2011 update. S Afr Med J 2011; 101(1 Pt 2): 63–73.
33 Mohammed J, Derom E, Van Oosterwijck J, Da Silva H, Calders P. Evidence for aerobic exercise training on the autonomic function in patients with chronic obstructive pulmonary disease (COPD): a systematic review. Physiotherapy 2018; 104(1): 36–45.
34 Ba A, Brégeon F, Delliaux S, Cissé F, Samb A, Jammes Y. Cardiopulmonary response to exercise in COPD and overweight patients: relationship between unloaded cycling and maximal oxygen uptake profiles. Biomed Res Int 2015; 2015: 378469.
35 Desalu O O, Onyedum C C, Adeoti A O, et al. Guideline-based COPD management in a resource-limited setting—physicians' understanding, adherence and barriers: a cross-sectional survey of internal and family medicine hospital-based physicians in Nigeria. Prim Care Respir J 2013; 22(1): 79–85.
36 Tadyanemhandu C, Mupanda C, Dambi J, Chiwaridzo M, Chikwasha V, Chengetanai S. Human immunodeficiency virus associated pulmonary conditions leading to hospital admission and the pulmonary rehabilitation services received by patients at two central hospitals in Harare. BMC Res Notes 2018; 11: 407.
37 Morrow B, Brink J, Grace S, Pritchard L, Lupton-Smith A. The effect of positioning and diaphragmatic breathing exercises on respiratory muscle activity in people with chronic obstructive pulmonary disease. S Afr J Physiother 2016; 72(1): 315.
38 Clarke H, Voss M. The role of a multidisciplinary student team in the community management of chronic obstructive pulmonary disease. Primary Health Care Res Dev 2016; 17: 415–420.
39 de Grass D, Manie S, Amosun S L. Effectiveness of a home-based pulmonary rehabilitation programme in pulmonary function and health related quality of life for patients with pulmonary tuberculosis: a pilot study. Afr Health Sci 2014; 14(4): 866–872.
40 Shaw B S, Shaw I. Pulmonary function and abdominal and thoracic kinematic changes following aerobic and inspiratory resistive diaphragmatic breathing training in asthmatics. Lung 2011; 189: 131–139.
41 Jones R, Kirenga B J, Katagira W, et al. A pre-post intervention study of pulmonary rehabilitation for adults with post-tuberculosis lung disease in Uganda. Int J Chron Obstruct Pulmon Dis 2017; 12: 3533–3539.
42 Jones R, Muyinda H, Nyakoojo G, Kirenga B, Katagira W, Pooler J. Does pulmonary rehabilitation alter patients' experiences of living with chronic respiratory disease? A qualitative study. Int J Chron Obstruct Pulmon Dis 2018; 13: 2375–2385.
43 Ige O M, Olarewaju R K, Lasebikan V O, Adeniyi Y O. Outpatient pulmonary rehabilitation in severe chronic obstructive pulmonary disease. Indian J Chest Dis Allied Sci 2010; 52: 197–201.
44 Islam M, Iqbal U, Walther B, et al. Benzodiazepine use and risk of dementia in the elderly population: a systematic review and meta-analysis. Neuroepidemiology 2016; 47: 181–191.
45 Dubé B-P, Vermeulen F, Laveneziana P. Exertional dyspnoea in chronic respiratory diseases: from physiology to clinical application. Arch Bronconeumol 2017; 53(2): 62–70.
46 Holland A E, Wadell K, Spruit M A. How to adapt the pulmonary rehabilitation programme to patients with chronic respiratory disease other than COPD. Eur Respir Rev 2013; 22: 577–586.
47 Rochester C L, Vogiatzis I, Holland A E, et al. An official American Thoracic Society/European Respiratory Society Policy statement: enhancing implementation, use, and delivery of pulmonary rehabilitation. Am J Respir Crit Care Med 2015; 192(11): 1373–1386.

48 Patel S, Cole A D, Nolan C M, et al. Pulmonary rehabilitation in bronchiectasis: a propensity-matched study. Eur Respir J 2019; 53: 1801264.
49 Muñoz-Torrico M, Rendon A, Centis R, et al. Is there a rationale for pulmonary rehabilitation following successful chemotherapy for tuberculosis? J Bras Pneumol 2016; 42(5): 374–385.
50 Aggarwal D, Gupta A, Janmeja A K, Bhardwaj M. Evaluation of tuberculosis-associated chronic obstructive pulmonary disease at a tertiary care hospital: a case–control study. Lung India 2017; 34(5): 415–419.
51 Lacasse Y, Goldstein R, Lasserson T J, Martin S. Pulmonary rehabilitation for chronic obstructive pulmonary disease. Cochrane Database Syst Rev 2006; (4): CD003793.
52 Maltais F, Bourbeau J, Shapiro S, et al. Effects of home-based pulmonary rehabilitation in patients with chronic obstructive pulmonary disease. Ann Intern Med 2008; 149: 869–878.
53 Burge A T, Holland A E, McDonald C F, et al. Home-based pulmonary rehabilitation for COPD using minimal resources: an economic analysis. Respirology 2020; 25(2): 183–190.
54 Jenkins S, Hill K, Cecins N M. State of the art: how to set up a pulmonary rehabilitation program. Respirology 2010; 15: 1157–1173.
55 Fabre C, Chehere B, Bart F, Mucci P, Wallaert B, Grosbois J M. Relationships between heart rate target determined in different exercise testing in COPD patients to prescribed with individualized exercise training. Int J Chron Obstruct Pulmon Dis 2017; 12: 1483–1489.
56 Singh S. Approaches to outcome assessment in pulmonary rehabilitation. Clin Chest Med 2014; 35(2): 353–361.
57 Rochester C L, Spanevello A. Heterogeneity of pulmonary rehabilitation: like apples and oranges—both healthy fruit. Eur Respir J 2014; 43(5): 1223–1226.
58 Williamson P R, Altman D G, Blazeby J M, et al. Developing core outcome sets for clinical trials: issues to consider. Trials 2012; 13: 132.
59 Hoppe L E. Developing core outcome sets for clinical research and guideline development – qualitative systematic reviews to increase the volume, depth and diversity of patient perspectives included. Tuberculosis: a case study [Thesis]. Manchester, UK: University of Manchester, 2016.https: //www.research.manchester.ac.uk/portal/en/theses/developing-core-outcome-sets-for-clinical-research-and-guideline-development–qualitative-systematic-reviews-to-increase-the-volume-depth-and-diversity-of-patient-perspectives-includedtuberculosis-a-case-study(26909892-647b-46cb-b82e-e7bc7f539f3e).html
60 Williamson P R, Altman D G, Bagley H, et al. The COMET handbook: version 1.0. Trials 2017; 18 (Suppl 3): 280.
61 Souto-Miranda S, Marques A. Triangulated perspectives on outcomes of pulmonary rehabilitation in patients with COPD: a qualitative study to inform a core outcome set. Clin Rehab 2019; 33(4): 805–814.
62 Moher D, Hopewell S, Schulzc K F, et al. CONSORT 2010 Explanation and elaboration: updated guidelines for reporting parallel group randomised trials. J Clin Epidemiol 2010; 63(8): e1–e37.

RÉSUMÉ

CONTEXTE : La rééducation pulmonaire (PR) est un traitement non médicamenteux très efficace pour les patients atteints de maladies respiratoires chroniques.

OBJECTIF : Synthétiser les preuves de pratique et d'efficacité de la PR en Afrique sub-saharienne.

MÉTHODE : Nous avons recherché sur PubMed et Scopus des études pertinentes ainsi que des listes de références scannées d'études supplémentaires à partir de ces bases de données. Les articles répondant aux critères ont été inclus. Des données prédéterminées ont été extraites indépendamment par deux réviseurs. Une approche par synthèse narrative a été utilisée pour l'interprétation des résultats.

RÉSULTATS : Six études ont été incluses, pour un total de 275 participants. Les indications de PR ont été les maladies pulmonaires chroniques obstructives, l'asthme, la tuberculose pulmonaire et les pathologies pulmonaires post-tuberculose. Les programmes de rééducation ont fonctionné pendant 6–12 semaines, ont tous incorporé de l'exercice physique et ont été réalisés soit à domicile soit en hôpital. Toutes les études ont été des interventions et deux ont été des essais randomisés contrôlés et ont principalement rapporté les paramètres de la fonction pulmonaire et de la tolérance à l'exercice. Des éléments d'individualisation du programme d'exercice physique ont été disponibles dans trois études.

CONCLUSION : Il y a peu d'information relative à la conception et à l'efficacité de la PR en Afrique sub-saharienne, mais les données disponibles sont en faveur de son utilisation dans un ensemble de pathologies respiratoires chroniques. Les études futures devraient rapporter les principaux résultats obtenus et leurs protocoles individualisés d'exercice et d'éducation.

RESUMEN

MARCO DE REFERENCIA: La rehabilitación respiratoria (PR) es un tratamiento no farmacológico muy eficaz para los pacientes con enfermedades pulmonares crónicas.

OBJETIVO: Sintetizar la evidencia sobre la práctica y la eficacia de la PR en África subsahariana.

MÉTODO: Se realizó una búsqueda de artículos pertinentes en las bases de datos PubMed y Scopus y se examinaron las listas de referencias de los artículos escogidos para encontrar otros estudios. Se incluyeron los artículos que cumplían los criterios de inclusión. Dos revisores extrajeron de manera independiente los datos predeterminados. Los hallazgos se interpretaron mediante una estrategia de síntesis narrativa.

RESULTADOS: Se incluyeron seis estudios con un total de 275 participantes. Las indicaciones de la PR eran enfermedad pulmonar obstructiva crónica, asma, tuberculosis pulmonar y enfermedad pulmonar postuberculosis. Los programas duraban de 6–12 semanas, todos comportaban ejercicios y utilizaban diversamente un modelo de ejecución en los hogares o en los hospitales. Todos los estudios eran intervencionistas y dos de ellos eran ensayos aleatorizados y notificaban como principales criterios de evaluación, esencialmente la función respiratoria y la tolerancia al ejercicio. Tres estudios contenían información sobre la individualización del esquema de ejercicios.

CONCLUSIÓN: La evidencia sobre el diseño y la eficacia de la PR en África subsahariana es limitada, pero se cuenta con datos que respaldan su utilización en una diversidad de afecciones respiratorias crónicas. Serían útiles estudios futuros que comuniquen conjuntos básicos de criterios de evaluación, sus esquemas de ejercicios individualizados y los programas educativos.