Review Article

Pulmonary rehabilitation for COPD: A narrative review and call for further implementation in Saudi Arabia

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Abstract:

Chronic obstructive pulmonary disease (COPD) is a common, preventable, and treatable condition, in which outcomes can be improved with careful management. Pulmonary rehabilitation (PR) comprises exercise and education, delivered by multidisciplinary teams. PR is a cost-effective management strategy in COPD patients which improves exercise performance, reduces dyspnea, reduces the risk of exacerbation, and improves health-related quality of life. All COPD patients appear to benefit irrespective of their baseline function, and PR has also been shown to be a clinically and cost-effective management approach following an acute exacerbation. COPD patients with greater disability and those recovering postexacerbation should be specifically targeted for PR. Due to limited current capacity, the latter group may not currently be able to benefit from PR. Therefore, there is a need for the wider implementation of PR services in Saudi Arabia, requiring us to address challenges including capacity and workforce competency.

Keywords:

Chronic obstructive pulmonary disease, pulmonary rehabilitation, Saudi Arabia

In simple terms, chronic obstructive pulmonary disease (COPD) is a progressive lung condition associated with poorly reversible airflow obstruction. COPD is a common cause of morbidity and mortality worldwide.[1] Individuals with COPD tend to have daily symptoms such as dyspnea, cough with or without sputum production, wheeze, and chest tightness. They also have reduced exercise capacity and increased susceptibility to periodic chest infections or worsening of their symptoms, referred to as "exacerbations" that might lead to hospital admissions.[2]

The Global Initiative for Obstructive Lung Disease strategy document summarizes current approaches to COPD management.[3] Cost-effective treatment approaches for stable COPD, described in the London respiratory "Value Pyramid," include smoking cessation, influenza vaccination, and pulmonary rehabilitation (PR).[4] PR is a multidisciplinary program that offers exercise training and education to improve the quality of life and exercise performance in patients with chronic respiratory disease.[5-8] Multiple high-quality randomized controlled trials (RCTs) and meta-analysis have demonstrated that PR is a cost-effective management strategy in COPD, and more cost-effective compared to pharmacologic intervention.[5-10] As PR is recognized as an effective nonpharmacological management approach in COPD, there is the need for greater implementation including in Saudi Arabia. This review summarizes the

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history of PR, program content and structure, and the effectiveness of PR in COPD as a resource to further support the provision of PR services in Saudi Arabia.

Methods

We conducted a narrative review of the history, program content and structure, and the effectiveness of PR with COPD patients. A literature search was performed using PubMed, Medline, EMBASE, and Google Scholar with keywords of PR, PR, rehabilitation, exercise, pulmonary disease, chronic pulmonary disease, chronic obstructive lung disease, lung disease, emphysema, chronic bronchitis, Saudi Arabia, and KSA. Only English language full articles were reviewed to identify the current evidence.

History and Definition

The importance of physical activity and healthy diet in respiratory disease were first introduced in 1895 by Dr. Denison, Professor of Diseases of the Chest and of Climatology at the University of Denver, in his book titled *Exercise and Food for Pulmonary Invalids*.[11]

In the middle of the 20th century, Barach *et al*. conducted a study which involved patients with pulmonary emphysema to investigate how to reduce dyspnea.[12] They discovered that using oxygen therapy alone in two patients reduced their dyspnea during daily activities. When an exercise program was initiated for these two patients, a remarkable improvement in dyspnea and exercise capacity, as measured by daily steps, were observed. Ten years later, Brach recommended exercise training be routinely integrated into the management of patients with chronic lung diseases. Physical therapy and breathing retraining were reported to be beneficial for patients with pulmonary emphysema, and the twin components of education and exercise are still considered fundamental components of PR today.[12]

Thomas Petty was the first to describe the short-term and long-term benefits of exercise programs for individuals with chronic airway obstruction such as COPD.[13] Petty described the necessary components of the exercise program, starting with an initial evaluation of patients followed by daily instruction lasting 1 h, together with training in airway clearance and breathing techniques, with tailored exercises and home visits. At the end of the program, and 1 year later, Petty re-evaluated the patients and reported that there was an improvement in daily symptoms, exercise capacity, hospitalization, and length of hospital stay.

The benefits of PR are may not be easily understood by patients with reduced lung function and limited exercise abilities, who may believe their physical function is irreversible; thus, it may be hard to persuade patients to exercise. Nonspecialist clinicians, too, may have poor understanding of PR making it challenging to refer their COPD patients or advocate for this approach. In 1992, an influential European report stated that PR was a beneficial management approach for individuals with COPD.[14] According to this European Respiratory Society (ERS) taskforce, PR aims to: "(1) decrease physical and psychological impairment due to the disease, (2) increase physical and mental fitness and performance, and (3) maximize social reintegration of the patient to lower the handicap."

PR consists of both individually tailored exercise and education, in which the exercise component consists of aerobic exercise for both lower and upper limbs. The beneficial effects of PR can be acquired regardless of patients' smoking status, age, sex, or degree of lung function abnormality. Based on the evidence supporting PR, several guidelines and organizations have recommended that every symptomatic COPD patient is referred to a PR program. Many national and international societies have issued statements and positions on PR. In 1981, the first official definition of PR was published by the American Thoracic Society (ATS), in which PR was defined as "an art of medical practice wherein an individually tailored, multidisciplinary program is formulated which through accurate diagnosis, therapy, emotional support and education, stabilizes or reverses both the physio-and psychopathology of pulmonary diseases and attempts to return the patient to the highest possible capacity allowed by his pulmonary handicap and overall life situation."[15] Recently, PR has been defined by the ERS and ATS as "an evidence-based, multidisciplinary, and comprehensive intervention for patients with chronic respiratory diseases who are symptomatic and often have decreased daily life activities."[16] The British Thoracic Society (BTS) defined PR as "an interdisciplinary program of care for patients with chronic respiratory impairment that is individually tailored and designed to optimize each patient's physical and social performance and autonomy. Programs comprise individualized exercise programs and education."[17] The BTS go on to emphasize that PR is a comprehensive management approach whose components should improve exercise capacity, breathing retraining, disease education, pharmacological usage, and psychological and nutritional support.[17]

Aims and Effectiveness

PR reduces COPD exacerbations, hospitalization, unscheduled hospital visits, symptoms of dyspnea, leg discomfort, anxiety and depression, and health-care costs in people with COPD.[18] PR significantly improves exercise capacity, muscle strength and endurance, emotional function, health-related quality of life, exercise

capacity, disease self-management, nutritional status, and likelihood of improving physical activities in people with COPD.[10,16,19-22]

A major goal of PR is to enhance exercise capacity, which is usually limited by shortness of breath and/or muscle fatigue in individuals with chronic respiratory diseases, and to promote self-dependency in relation to activities of daily living.[23] When an individual with COPD avoids activities that result in breathlessness, peripheral muscle weakness occurs. As weak muscles require more oxygen to perform activities, COPD patients become more breathless. This is referred to as the vicious cycle of inactivity [Figure 1]. It is essential to differentiate between exercise capacity and physical activity. The World Health Organization has defined physical activity as "any bodily movement produced by skeletal muscles that requires energy expenditure – including activities undertaken while working, playing, carrying out household chores, travelling, and engaging in recreational pursuits," whereas exercise capacity is the capability of someone to tolerate exercise, which usually consists of multiple physical activities to improve physical fitness.[24,25]

PR program is best administered by a multidisciplinary team that includes but is not limited to doctors, nurses, physiotherapists, psychologists, occupational therapists, dietitians or nutritionists, psychologists, and social workers.

Functional or maximal exercise capacity and health-related quality of life are used to assess the effectiveness of

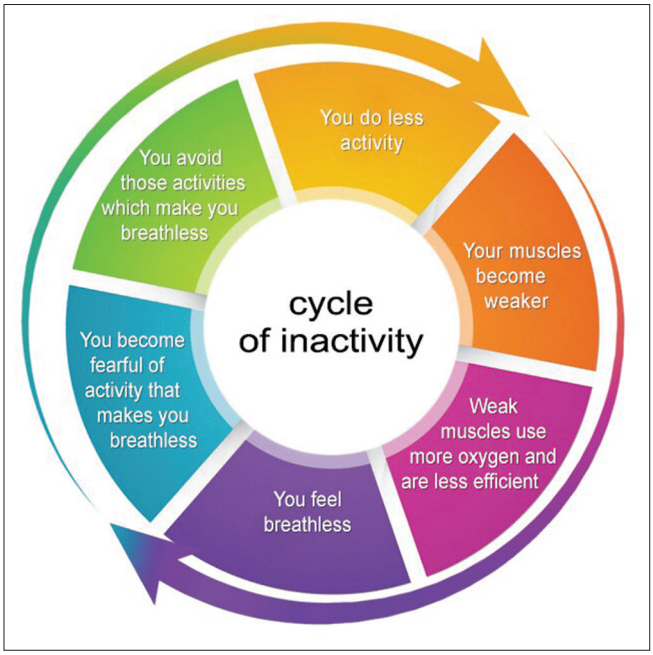

Figure 1: Vicious cycle of inactivity in chronic obstructive pulmonary disease patients

PR in program participants. Exercise capacity evaluation is usually performed before starting and at the end of a program.[26] The incremental shuttle walk test (ISWT) and 6-min walk test (6MWT) are the most common field tests used for evaluating exercise capacity.[27] The ISWT is a maximum exercise test, with 12 min as the maximum duration, where the patient walks between two cones 10 m apart and an audio recording plays the test instructions.[28] By contrast, the 6MWT is a submaximal exercise test to measure the patient's ability to walk back and forth on a marked 30-m hallway for 6 min, and rest is allowed if needed.[28] To identify the impact of ISWT or 6MWT, oxygen saturation, heart rate, and level of dyspnea are measured before and after the field walking tests. ISWT and 6MWT field tests are both valid and reliable for measuring exercise capacity function and the effectiveness of a PR intervention in patients with chronic lung disease.[28]

Individuals with COPD have shown an improvement in confidence by modifying behaviors in the safe multidisciplinary environment of a PR class.[25] Troosters reported that high-intensity exercise training during PR reduces oxygen requirements by minimizing sensitivity to dyspnea and reverses peripheral muscle abnormalities by improving oxidative capacity.[29] PR positively impacted COPD patients' perception of shortness of breath, improved their levels of confidence, and lowered fear, resulting in a favorable impact on patients' quality of life.[30] COPD patients are advised to increase their physical activities outside the class, as this can further enhance their independence. During PR, COPD patients become better at managing their symptoms and through sharing experience and knowledge with other patients with the same condition and their health-care practitioner.[31,32] PR therefore also improves functional outcomes such as walking and quality of life by reducing the unfavorable adverse psychological effects of the disease.[10] COPD patients with ventilatory disturbances and muscle dysfunction demonstrate a significant benefit from attending a PR program.[10] The benefits of PR might not be maintained as the effect might differ for each patient, but those patients who do benefit from PR are more likely to continue exercising after the end of the PR program and are the most likely to attend for future PR.[33,34] COPD patients who have been referred to PR more than once are more likely to maintain the benefits of PR for 3 months up to a year.[35]

Location and Mode of Delivery

Globally, regular PR attendance depends on accessible locations and methods of delivery.[10,13] Commonly, PR is delivered as a center-based class where patients are assessed and monitored by a multidisciplinary team. Center-based PR can be applied in inpatient or outpatient settings and

each has advantages and disadvantages. Inpatient PR is usually delivered in hospitals for patients who also need daily medical care, especially for those in acute care, or during stable status for those with more severe functional disabilities. Outpatient PR, the more common model, is usually provided in outpatient clinics, ambulatory care, or community facilities. Outpatient PR programs need to address accessibility, access to equipment, and specialized staff. Home-based PR programs (supervised or unsupervised) are an additional form of PR, in which the exercise training components are transferred to home settings and a specialist provides certain support such as home visits, education, and monitoring. Recently, there has been increased demand for home-based PR which can be facilitated through digital technologies. Telehealth has been used for COPD patients for several purposes such as patient monitoring, and it considered to be effective.[36,37] However, using Telehealth to deliver PR is relatively new. Using this technology during the COVID-19 pandemic may be one way to maintain PR, since COPD are at higher risk of mortality.[38] With technology, access to technology-PR service applications such as but not limited to "myPR" and "SPACE" can be broadened and patients' progress can be remotely monitored by health-care providers.[39-41] These health-care providers are virtually present during the PR program which takes place in the patient's home with the help of video conferencing in the Internet-based PR.[42] However, telehealth PR implementation may face significant challenges such as limited lack of technical competency within PR teams and patients.[42]

The content of PR programs varies with regard to capacity, intensity of exercise, length, and number of sessions.[43] According to the 2018 United Kingdom National PR audit, there were remarkable differences around the UK between programs in location, care process, referral criteria, PR health-care teams, and patients' attendance.[43] For instance, some PR services accept self-referral, re-referral, or auto-referral after being hospitalized, while other PR services do not. The majority of PR services in the UK had multidisciplinary teams including physiotherapists, nurses, dieticians, and occupational therapists to administer PR. The UK does not have the role of respiratory therapist, as is common in Saudi Arabia. However, access to respiratory physicians and psychologists is restricted in some PR services.[44] PR service locations may vary, with some programs taking place at convenience or community centers, practice surgeries, hospitals, or at home using technology.[43] The Saudi Thoracic Society (STS) guidelines recommend that PR services should have access to pulmonologist or thoracic surgeon.[45]

Patient Selection

The UK National PR audit reported variations in the services being provided and the acceptability criteria for enrolment on PR programs. For instance, only 8% of PR programs in the UK accept patients who are in the late stage of their disease process and have an Medical Research Council (MRC) Grade of 5. BTS guidelines recommend that COPD patients who are admitted to hospitals with acute exacerbations of COPD should be referred to PR at discharge, as exacerbation has an undesirable psychological and physical impact on patients. According to the National PR audit report, only 71% of PR services accept early posthospital discharge referral, while 29% of PR services offer this 1 month after hospital discharge. Therefore, PR audit recommended that PR service providers and leaders should establish clear and standard referral criteria. Furthermore, they recommend offering PR service to patients with an MRC score of 2–5, despite their exercise capacity status and disease severity.[43]

The BTS guidelines summarized the essential components of an effective PR program. Effective PR should consist of exercise, self-management, and education, nutritional, and psychological support. The BTS guidelines on PR recommended that PR duration should be of 6–12 weeks of supervised sessions, 12 sessions a minimum, because this increases the chance of patient improvement.[17] The STS guidelines recommended that PR duration should be of 8–12 weeks of twenty supervised sessions.[45]

In April 2018, the Royal College of Physicians (RCP) lunched the PR Services Accreditation Scheme aiming to benchmark and improved the quality of delivered PR services to patient across the UK. The PR audit is part of RCP and National Asthma and COPD Audit Programme that monitors service and delivery of PR, a snapshot audit of the organization and resourcing of services and an accreditation program.

Patient Suitability for Pulmonary Rehabilitation

The UK National Institute for Health and Care Excellence (NICE) guidelines recommend a PR program for patients who have mobility disability and scored 3–5 on the MRC dyspnea score. The BTS supported the NICE guidelines and highlighted the importance of referral within 4 weeks of hospital discharge for patients who hospitalized with COPD.[17] The STS guidelines recommend that PR should be offered to COPD patients with an forced expiratory volume in 1 s (FEV_1) of at least 50% of the predicted value, those who are symptomatic with FEV_1 between 50% and 80%, or those with a CAT score of more than 10.[45]

The MRC breathlessness scale is considered one of the most common scales used for referring individuals to PR. However, the health-care provider should not only

rely on the MRC breathlessness scale as it too insensitive to detect improvement or deterioration during PR. BTS recommended that health-care providers should have sufficient knowledge about PR and its benefit before referral to educate, motivate, and encourage patients to start PR.[17] Therefore, there is a need to provide sufficient training for health-care student and providers to facilitate the current practice and recommendations for referring patients to PR services.

Pulmonary Rehabilitation for Disorders Other than Chronic Obstructive Pulmonary Disease

PR has been prescribed as a part of management for patients with other chronic lung diseases such as interstitial lung disease (ILD), bronchiectasis, pulmonary hypertension (PH), and lung cancer to improve symptoms, exercise capacity, and quality of life. ILD is a group of lung diseases that are characterized by scarring or fibrosis of interstitial lung tissue. Individuals with ILD experience dyspnea and have a reduction in exercise capacity, strength, and endurance.[46] In patients with ILD, PR is effective in mitigating dyspnea, improving exercise capacity, and quality of life.[47] Bronchiectasis is characterized by a chronic cough with sputum production. Like many other lung diseases, patients with bronchiectasis are susceptible to exacerbations and may present with reduced exercise capacity.[48] PR is an efficient treatment approach in improving exercise capacity, quality of life, and reducing exacerbation in bronchiectasis.[49,50]

In the past, PR was avoided in patients with PH, as it was thought that PR might accelerate heart failure and increase mortality.[51] However, a recent Cochrane review on PR for individuals with stable PH was published, including six RCTs, reporting improvements in exercise capacity and quality of life without reported adverse events.[52] Components of PR should be similar to chronic heart disease and COPD. Generally, individuals with lung cancer join PR to manage their symptoms and minimize functional impairment in order to become fitter for lung resection surgery.

Pulmonary Rehabilitation in Saudi Arabia

Despite tremendous efforts in COPD management, the disease is still underdiagnosed worldwide including in Saudi Arabia.[53] In Saudi Arabia, smoking is highly prevalent among adolescent and around 4.2% of adults over the age of 40 years live with COPD.[54,55] Individuals in Saudi Arabia widely rely on personal transportation in daily live which affects their level of fitness and might lead to physical inactivity that can already be noticed among youth and adult.[56] Individuals with COPD usually have limited physical activity, in relation to daily living, due to shortness of breath and/or muscle fatigue which could be minimized by joining a PR program. PR services in Saudi Arabia were launched in 2001 but are not widely utilized. To the best of our knowledge, there are a limited number of programs running in Saudi Arabia with no program offered in the Eastern Province. Even where they are running, PR may be under publicized, which makes it hard for stakeholders (patients and interested clinician) to contact programs to seek information about enrolment or further program-related information.[57] The feasibility of the first program, at King Abdulaziz Medical City, was tested in 2008 by Al-Moamary, which showed outpatient PR was feasible in patients with chronic lung diseases in Saudi.[58] The effect of outpatient and home-based PR was tested in individuals with chronic lung diseases and PR had positive effects on exercise capacity, quality of life, and overall level of fitness.[58-60] Adherence has been one of the main issues in providing PR. In Saudi Arabia, a study was conducted in 2008 to determine the feasibility and adherence rate among COPD patients and found that implementation a PR program in a tertiary hospital in Saudi Arabia resulted in an adherence rate of 57.2%,[61] which explains the readiness of tertiary centers to provide comprehensive and convenient PR programs. However, there are considerable barriers such as absence of standardized national guidelines, transportation, hospital capacity, trained health-care professionals, and budget coverage which all play an essential role in formulating, structuring, and expanding PR services in the kingdom.[62] Transportation and hospital capacity were considered the main barriers for starting a PR program;[62] however, PR can be provided in other settings such as community-based or/and home. The lack of trained health-care providers involved in the care of COPD patients has been reported previously.[63] Provide training and incentives to current staff and encourage future health-care providers to be specialized in respiratory diseases might solve staff shortage. Funding is a barrier for setting up and continue a PR service due to free health services provided by the government; therefore, it is essential to convince the health-care authority in Saudi Arabia that PR is a cornerstone in the management of COPD and other respiratory diseases.

Conclusion

PR is an effective nonpharmacological intervention for chronic respiratory conditions. Despite the wide range of PR services, there remains further need for PR services in Saudi Arabia and challenges to address include the multiprofessional teams and expertise necessary to establish and run such programs.

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Conflicts of interest
There are no conflicts of interest.

References

1. Mathers CD, Loncar D. Projections of global mortality and burden of disease from 2002 to 2030. PLoS Med 2006;3:e442.
2. Alqahtani JS, Njoku CM, Bereznicki B, Wimmer BC, Peterson GM, Kinsman L, *et al*. Risk factors for all-cause hospital readmission following exacerbation of COPD: A systematic review and meta-analysis. Eur Respir Rev 2020;29:190166.
3. Vogelmeier CF, Criner GJ, Martinez FJ, Anzueto A, Barnes PJ, Bourbeau J, *et al*. Global strategy for the diagnosis, management, and prevention of chronic obstructive lung disease 2017 report. GOLD executive summary. Am J Respir Crit Care Med 2017;195:557-82.
4. Zoumot Z, Jordan S, Hopkinson NS. Emphysema: Time to say farewell to therapeutic nihilism. Thorax 2014;69:973-5.
5. Wüst RC, Degens H. Factors contributing to muscle wasting and dysfunction in COPD patients. Int J Chron Obstruct Pulmon Dis 2007;2:289-300.
6. Lareau, SC, Fahy, B. Patient information series: Pulmonary rehabilitation. Am J Respir Crit Care Med American Thoracic Society 2013;198:19–20.
7. Nici L, Donner C, Wouters E, Zuwallack R, Ambrosino N, Bourbeau J, *et al*. American Thoracic Society/European respiratory society statement on pulmonary rehabilitation. Am J Respir Crit Care Med 2006;173:1390-413.
8. Evans RA, Singh SJ. Minimum important difference of the incremental shuttle walk test distance in patients with COPD. Thorax. 2019;74:994-5.
9. Ries AL, Bauldoff GS, Carlin BW, Casaburi R, Emery CF, Mahler DA, *et al*. Pulmonary rehabilitation: Joint ACCP/AACVPR evidence-based clinical practice guidelines. Chest 2007;131:4S-42S.
10. McCarthy B, Casey D, Devane D, Murphy K, Murphy E, Lacasse Y. Pulmonary rehabilitation for chronic obstructive pulmonary disease. Cochrane Database Syst Rev 2015;23:CD003793.
11. Spruit MA, Burtin C, De Boever P, Langer D, Vogiatzis I, Wouters EF, *et al*. COPD and exercise: Does it make a difference? Breathe (Sheff) 2016;12:e38-49.
12. Barach AL, Bickerman HA, Beck G. Advances in the treatment of non-tuberculous pulmonary disease. Bull N Y Acad Med 1952;28:353-84.
13. Spruit MA, Clini EM. Towards health benefits in chronic respiratory diseases: Pulmonary rehabilitation. Eur Respir Rev 2013;22:202-4.
14. Donner CF, Howard P. Pulmonary rehabilitation in chronic obstructive pulmonary disease (COPD) with recommendations for its use. Report of the European Respiratory Society Rehabilitation and Chronic Care Scientific Group (S.E.P.C.R. Rehabilitation Working Group). Eur Respir J 1992;5:266-75.
15. Hodgkin JE, Farrell MJ, Gibson SR, Kanner RE, Kass I, Lampton LM, *et al*. American thoracic society. Medical section of the American Lung Association. Pulmonary rehabilitation. Am Rev Respir Dis 1981;124:663-6.
16. Gibson GJ, Loddenkemper R, Lundbäck B, Sibille Y. Respiratory health and disease in Europe: The new European Lung White Book. Eur Respir J 2013;42:559-63.
17. Bolton CE, Singh SJ, Walker PP, British Thoracic Society Pulmonary Rehabilitation Guideline Group. Commentary: The British Thoracic Society guideline on pulmonary rehabilitation in adults. Thorax 2013;68:887-8.
18. Moore E, Palmer T, Newson R, Majeed A, Quint JK, Soljak MA. Pulmonary rehabilitation as a mechanism to reduce hospitalizations for acute exacerbations of COPD: A systematic review and meta-analysis. Chest 2016;150:837-59.
19. Janssens T, De Peuter S, Stans L, Verleden G, Troosters T, Decramer M, *et al*. Dyspnea perception in COPD: Association between anxiety, dyspnea-related fear, and dyspnea in a pulmonary rehabilitation program. Chest 2011;140:618-25.
20. Paz-Díaz H, Montes de Oca M, López JM, Celli BR. Pulmonary rehabilitation improves depression, anxiety, dyspnea and health status in patients with COPD. Am J Phys Med Rehabil 2007;86:30-6.
21. Aldabayan YS, Ridsdale HA, Alrajeh AM, Aldhahir AM, Lemson A, Alqahtani JS, *et al*. Pulmonary rehabilitation, physical activity and aortic stiffness in COPD. Respir Res 2019;20:166.
22. Alqahtani JS, Oyelade T, Sreedharan J, Aldhahir AM, Alghamdi SM, Alrajeh AM, *et al*. Diagnostic and clinical values of non-cardiac ultrasound in COPD: A systematic review. BMJ Open Respir Res 2020;7:e000717.
23. Steiner MC, Roberts CM. Pulmonary rehabilitation: The next steps. Lancet Respir Med 2016;4:172-3.
24. Global Recommendations on Physical Activity for Health. Switzerland: World Health Organization; 2010.
25. Troosters T, van der Molen T, Polkey M, Rabinovich RA, Vogiatzis I, Weisman I, *et al*. Improving physical activity in COPD: Towards a new paradigm. Respir Res 2013;14:115.
26. Jenkins S, Cecins NM. Six-minute walk test in pulmonary rehabilitation: Do all patients need a practice test? Respirology 2010;15:1192-6.
27. Clini E, Holland AE, Pitta F, Troosters T. Textbook of Pulmonary Rehabilitation. New York: Springer International Publishing; 2018.
28. Holland AE, Spruit MA, Troosters T, Puhan MA, Pepin V, Saey D, *et al*. An official European Respiratory Society/American Thoracic Society technical standard: Field walking tests in chronic respiratory disease. Eur Respir J 2014;44:1428-46.
29. Troosters T, Gosselink R, Janssens W, Decramer M. Exercise training and pulmonary rehabilitation: New insights and remaining challenges. Eur Respir Rev 2010;19:24-9.
30. Williams V, Bruton A, Ellis-Hill C, McPherson K. The effect of pulmonary rehabilitation on perceptions of breathlessness and activity in COPD patients: A qualitative study. Prim Care Respir J 2010;19:45-51.
31. Cooke M, Thackray S. Differences between community professional and patient perceptions of chronic obstructive pulmonary disease treatment outcomes: A qualitative study. J Clin Nurs 2012;21:1524-33.
32. Halding AG, Wahl A, Heggdal K. 'Belonging'. 'Patients' experiences of social relationships during pulmonary rehabilitation. Disabil Rehabil 2010;32:1272-80.
33. Morgan M. Expanding pulmonary rehabilitation capacity. One size won't fit all. Thorax 2017;72:4-5.
34. Rochester CL, Spruit MA. Maintaining the benefits of pulmonary rehabilitation. The holy grail. Am J Respir Crit Care Med 2017;195:548-51.
35. Busby AK, Reese RL, Simon SR. Pulmonary rehabilitation maintenance interventions: A systematic review. Am J Health Behav 2014;38:321-30.
36. Al Rajeh A, Steiner MC, Aldabayan Y, Aldhahir A, Pickett E, Quaderi S, *et al*. Use, utility and methods of telehealth for patients with COPD in England and Wales: A healthcare provider survey. BMJ Open Respir Res 2019;6:e000345.
37. Alrajeh AM, Aldabayan YS, Aldhair AM, Pickett E, Quaderi SA, Alqahtani JS, *et al*. Global use, utility, and methods of tele-health in COPD: A health care provider survey. Int J Chron Obstruct Pulmon Dis 2019;14:1713-9.
38. Alqahtani JS, Oyelade T, Aldhahir AM, Alghamdi SM,

Almehmadi M, Alqahtani AS, *et al*. Prevalence, Severity and Mortality associated with COPD and Smoking in patients with COVID-19: A Rapid Systematic Review and Meta-Analysis. PLoS One. 2020;15:e0233147. doi: 10.1371/journal.pone.0233147. PMID: 32392262; PMCID: PMC7213702.

39. Chaplin E, Hewitt S, Apps L, Bankart J, Pulikottil-Jacob R, Boyce S, *et al*. Interactive web-based pulmonary rehabilitation programme: A randomised controlled feasibility trial. BMJ Open 2017;7:e013682.
40. Bourne S, DeVos R, North M, Chauhan A, Green B, Brown T, *et al*. Online versus face-to-face pulmonary rehabilitation for patients with chronic obstructive pulmonary disease: Randomised controlled trial. BMJ Open 2017;7:e014580.
41. Alghamdi SM, Alqahtani JS, Aldhahir AM. Current status of telehealth in Saudi Arabia during COVID-19. J Family Community Med 2020;27:208-11.
42. Alaboudi A, Atkins A, Sharp B, Balkhair A, Alzahrani M, Sunbul T. Barriers and challenges in adopting Saudi telemedicine network: The perceptions of decision makers of healthcare facilities in Saudi Arabia. J Infect Public Health 2016;9:725-33.
43. Sally Singh ML, Garnavos N, Maclean-Steel K, Andrews R, Long N, Stone P, *et al*. National Asthma and Chronic Obstructive Pulmonary Disease Audit Programme (NACAP). Pulmonary Rehabilitation Clinical Audit 2019. Clinical Audit of Pulmonary Rehabilitation Services in England, Scotland and Wales. Patients Assessed between 1 March and 31 May and discharged by 31 August, 2019. London; 2020.
44. Spruit MA, Pitta F, Garvey C, ZuWallack RL, Roberts CM, Collins EG, *et al*. Differences in content and organisational aspects of pulmonary rehabilitation programmes. Eur Respir J 2014;43:1326-37.
45. Khan JH, Lababidi HM, Al-Moamary MS, Zeitouni MO, Al-Jahdali HH, Al-Amoudi OS, *et al*. The Saudi guidelines for the diagnosis and management of COPD. Ann Thorac Med 2014;9:55-76.
46. Mendes P, Wickerson L, Helm D, Janaudis-Ferreira T, Brooks D, Singer LG, *et al*. Skeletal muscle atrophy in advanced interstitial lung disease. Respirology 2015;20:953-9.
47. Dowman L, Hill CJ, Holland AE. Pulmonary rehabilitation for interstitial lung disease. Cochrane Database Syst Rev. 2014;6:CD006322.
48. de Camargo AA, Boldorini JC, Holland AE, de Castro RA, Lanza FC, Athanazio RA, *et al*. Determinants of peripheral muscle strength and activity in daily life in people with bronchiectasis. Phys Ther 2018;98:153-61.
49. Lee MS, Lee KS, Yang BK, Kim DS, Ha BM, Park K, *et al*. A framework for monitoring the malaria eradication programme in Korea. Asia Pac J Public Health 2003;15:44-9.
50. Lee AL, Hill CJ, McDonald CF, Holland AE. Pulmonary rehabilitation in individuals with non-cystic fibrosis bronchiectasis: A systematic review. Arch Phys Med Rehabil 2017;98:774-820.
51. Simonneau G, Montani D, Celermajer DS, Denton CP, Gatzoulis MA, Krowka M, *et al*. Haemodynamic definitions and updated clinical classification of pulmonary hypertension. Eur Respir J 2019;53:1801913.
52. Morris NR, Kermeen FD, Holland AE. Exercise-based rehabilitation programmes for pulmonary hypertension. Cochrane Database Syst Rev 2017;19;1.
53. Al Moamary MS, Tamim HM, Al-Mutairi SS, Al-Khouzaie TH, Mahboub BH, Al-Jawder SE, *et al*. Quality of life of patients with chronic obstructive pulmonary disease in the Gulf Cooperation Council countries. Saudi Med J 2012;33:1111-7.
54. Al Ghobain M, Alhamad EH, Alorainy HS, Al Kassimi F, Lababidi H, Al-Hajjaj MS. The prevalence of chronic obstructive pulmonary disease in Riyadh, Saudi Arabia: A BOLD study. Int J Tuberc Lung Dis 2015;19:1252-7.
55. Alasqah I, Mahmud I, East L, Usher K. A systematic review of the prevalence and risk factors of smoking among Saudi adolescents. Saudi Med J 2019;40:867-78.
56. Al-Hazzaa HM. Physical inactivity in Saudi Arabia revisited: A systematic review of inactivity prevalence and perceived barriers to active living. Int J Health Sci (Qassim) 2018;12:50-64.
57. Alsubaiei ME, Cafarella PA, Frith PA, McEvoy RD, Effing TW. Current care services provided for patients with COPD in the Eastern province in Saudi Arabia: A descriptive study. Int J Chron Obstruct Pulmon Dis 2015;10:2379-91.
58. Al-Moamary MS. Experience with pulmonary rehabilitation program in a tertiary care center in Saudi Arabia. Saudi Med J 2008;29:271-6.
59. Ghanem M, Elaal EA, Mehany M, Tolba K. Home-based pulmonary rehabilitation program: Effect on exercise tolerance and quality of life in chronic obstructive pulmonary disease patients. Ann Thorac Med 2010;5:18-25.
60. Al Moamary MS. Impact of a pulmonary rehabilitation programme on respiratory parameters and health care utilization in patients with chronic lung diseases other than COPD. East Mediterr Health J 2012;18:120-6.
61. Al Moamary MS. Health care utilization among chronic obstructive pulmonary disease patients and the effect of pulmonary rehabilitation. Med Princ Pract 2010;19:373-8.
62. Alsubaiei ME, Cafarella PA, Frith PA, McEvoy RD, Effing TW. Barriers for setting up a pulmonary rehabilitation program in the Eastern Province of Saudi Arabia. Ann Thorac Med 2016;11:121-7.
63. Almalki M, Fitzgerald G, Clark M. Health care system in Saudi Arabia: An overview. East Mediterr Health J 2011;17:784-93.