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Pulmonary rehabilitation in chronic obstructive pulmonary disease: A narrative review

Maria Jędryka[1], ORCID https://orcid.org/0009-0000-9052-8914

E-mail mjedryka2000@gmail.com

[1]Public Health Care Institution in Oława, Baczyńskiego 1, 55-200 Oława, Poland

Katarzyna Pagacz[2], ORCID https://orcid.org/0009-0000-1973-8433

E-mail pagkat2000@gmail.com

[2]The Lower Silesian Centre for Oncology, Pulmonology and Haematology, pl. Ludwika Hirszfelda 12, 53-413 Wrocław, Poland

Olga Kowalczyk[3], ORCID https://orcid.org/0009-0008-5105-3301

E-mail kowaalczykk@gmail.com

[3]Rev. J. Glowatzki County Hospital, ul. Opolska 36A, 47-100 Strzelce Opolskie, Poland

Bożena Kiełbasa[4], ORCID https://orcid.org/0009-0002-1667-124X

E-mail bozena.kielbasa00@gmail.com

[4]Tytus Chałubiński District Hospital in Zakopane, Kamieniec 10, 34-500 Zakopane, Poland

Wiktoria Kolasa[5], ORCID https://orcid.org/0009-0005-4809-7053
E-mail lekwiktoriakolasa@gmail.com
[5]Wrocław University Hospital, Borowska 213, 50-556 Wrocław, Poland

Aleksandra Stadnik[5], ORCID https://orcid.org/0009-0005-4764-3980
E-mail aleksandrastadnik2@gmail.com
[5]Wrocław University Hospital, Borowska 213, 50-556 Wrocław, Poland

Marta Kaczorek[6], ORCID https://orcid.org/0009-0007-1406-2076
E-mail kaczorek.marta1@gmail.com
[6]Institute of Psychiatry and Neurology, Sobieskiego 9, 02-957 Warsaw, Poland

Monika Lis[7], ORCID https://orcid.org/0000-0003-4021-919X
E-mail monikalis1267@gmail.com
[7]Mazovian "Bródnowski" Hospital, Ludwika Kondratowicza 8, 03-242 Warsaw, Poland

Julia Gatniejewska[8], ORCID https://orcid.org/0009-0001-1463-7497
E-mail juliaanna177@gmail.com
[8]Regional Hospital in Poznań, ul. Juraszów 7/19, Poznań 60-479, Poland

Corresponding Author
Maria Jędryka
E-mail mjedryka2000@gmail.com

Abstract

Background. Chronic obstructive pulmonary disease (COPD) is a potentially fatal respiratory disease characterised by persistent airflow obstruction, hyperinflation and poor pulmonary gas exchange. An important component of its non-pharmacological treatment is pulmonary rehabilitation (PR).

Aim. The aim of this review is to summarize current knowledge on PR and its influence on COPD patients' condition.

Material and methods. The narrative literature review was conducted using the PubMed and Google Scholar databases. This article included the most recent systematic reviews, meta-analyses, randomized trials and guidelines.

Results. PR is a multidisciplinary, comprehensive intervention designed to improve physical and psychological condition of patients with COPD. It should be based on an individualized, holistic approach. PR includes exercise training, education, and self-management, often supplemented by psychological and nutritional counseling. Education and self-management interventions support long-term behavioral change leading to optimal outcomes. Evidence shows that rehabilitation improves exercise capacity, reduces dyspnea, decreases anxiety and depression, and may reduce hospitalization rates and mortality following exacerbations and improve quality of life. Exercise training improves ventilatory efficiency, enhances muscle function, and has potential anti-inflammatory effects. Additionally, it can improve balance and reduce skeletal muscle dysfunction. Despite its proven effectiveness, PR is still underused due to various barriers, however its new forms enable easier access.

Conclusions. PR is a crucial component of COPD management. Individualized, multidisciplinary programs significantly improve patient outcomes and quality of life. New models of PR may increase patient participation.

Key words: pulmonary rehabilitation, chronic obstructive pulmonary disease, exercise training, self-management, telerehabilitation

1. Introduction

COPD is a respiratory disease that develops over several decades through exposure to noxious gases, mainly cigarette smoke and air pollution, inducing persistent airways inflammation leading to abnormalities of the airways (bronchitis, bronchiolitis) and/or alveoli (emphysema) that cause persistent, often progressive, airflow obstruction (FEV1/FVC < 0.7 post-

bronchodilation measured by spirometry), hyperinflation and poor pulmonary gas exchange.[1,2]

Symptoms of COPD typically develop in middle adulthood and include dyspnoea, wheezing, chest tightness, chronic cough with or without sputum production, fatigue and activity limitation as the condition progresses. Patients may experience acute events characterised by increased respiratory symptoms called exacerbations that influence their health status and prognosis, and require specific preventive and therapeutic measures including emergency hospitalization if required since exacerbations are potentially fatal.[3,4]

The treatment of COPD consists of pharmacological therapy and non-pharmacological therapy. The aim of treatment in COPD is to relieve dyspnoea and to reduce the probability of exacerbations. Pharmacotherapy is an important but not the sole component of the disease management. The other crucial interventions include smoking cessation, vaccination, treatment of comorbidities, self-management education, active lifestyle, PR, oxygen treatment and respiratory support if needed.[3]

PR is an important component of non-pharmacological management of COPD with untapped potential. 2026 GOLD Report uses PR definition created by The European Respiratory Society and the American Thoracic Society: a comprehensive intervention based on thorough patient assessment followed by patient-tailored therapies that include, but are not limited to, exercise training, education, self-management intervention aiming at behavior change, designed to improve the physical and psychological condition of people with COPD and to promote the long-term adherence to health-enhancing behaviors.[3] During rehabilitation process beside education, exercise training and breathing training patient might also need psychological and nutritional counselling, therefore PR requires a multidisciplinary team.[5] PR in COPD patients is based on a holistic approach leading to optimal patient management and a positive impact on the daily lives of individuals with COPD.

The importance of PR is highlighted by international organisations. WHO described a package of interventions for rehabilitation for patients with COPD in Module 4: Cardiopulmonary conditions. The Package of interventions for rehabilitation includes recommended therapeutic interventions, information on the required assistive products, equipment and consumables, and identifies the healthcare workforce with the qualifications necessary to deliver these interventions. It serves as an important resource to support countries when planning for and budgeting the integration of rehabilitation services into their health systems. This Package of interventions of rehabilitation for COPD is intended to be

used for adults with COPD including those recovering from an acute exacerbation and with certain specified COPD.[4]

Considering its impact on patients' health, PR should be available within a reasonable time from referral. Rehabilitation programme should be held at times that suit people with COPD and in locations that are easy for people with COPD to get to, and have good access for people with disabilities, in order to ensure universal access for patients.[6] Unfortunately, PR is underused despite clinical effectiveness and cost-effectiveness. Numerous barriers that challenge effective PR include problems with treatment adherence, transportation difficulty and long distances to be traveled to PR centres, geographic disparities with inadequate rural options, patients' limited knowledge about the course of the programme and its expected outcomes, beliefs regarding the role or safety of physical exercise, lack of confidence in the benefits of rehabilitation, disruption of daily responsibilities, competing priorities, inconvenient programme scheduling, long waiting times before programme initiation, comorbidities including depression, personnel-related barriers including limited number of PR professionals and limited training opportunities for PR professionals, inadequate PR reimbursement, lack of programme availability per se, greater focus on pharmacotherapy as compared to non-pharmacologic treatments for lung disease, perceptions that patients may lack motivation to participate, ambiguity as to whose role it is to refer patients, low knowledge of patient eligibility and of the referral process, lack of reminders for PR referral in the context of routine clinical workflow and resources to foster discussions of PR with patients.[7,8]

In this review we summarize current knowledge on PR and its effect on COPD patients' condition. We also analyse the key principles that should guide the development of PR programmes and examine emerging approaches used in respiratory rehabilitation.

2. Methodology

A search was conducted in PubMed and Google Scholar databases from January 2019 to June 2026. Used keywords include: pulmonary rehabilitation, chronic obstructive pulmonary disease, exercise training, self-management, telerehabilitation. In the analysis we included systematic reviews, meta-analyses, randomized trials and official guidelines.

3. Effects of exercise on COPD patients

Symptoms of COPD discourage patients from engaging in physical activity. When individuals with COPD engage in exercises that demand higher metabolic energy production, ventilatory

requirements increase which increases intensity of dyspnoea. In addition, poor gas exchange and increased dead space ventilation, which are observed in COPD, increase the ventilatory requirements for a given exercise and lead to even more symptoms of dyspnoea. In response, patients avoid exercise, associating it with triggering the symptoms.[2] Lack of physical activity leads to the development of comorbidities and decreases exercise tolerance. As a result pulmonary ventilation during exercises and dyspnoea continue to increase, leading to further physical activity avoidance.

Rehabilitation empowers people to develop strategies to perform activities despite symptoms and to regain and maintain their exercise capacity. Furthermore, rehabilitation supports people with COPD to keep engaged in meaningful activities, such as work and social life.[4] Therefore, PR programmes improve not only a person's exercise capacity and symptoms but also levels of anxiety and depression.[6] An additional benefit of exercise may be observed in patients with COPD–OSA overlap syndrome using positive airway pressure therapy. The addition of moderate intensity PR could increase the level of physical endurance and motor abilities, and in turn improve sleep apnoea, nocturnal hypoxia, body composition, and arterial blood gases.[9] Moreover, PR is associated with reduction in hospitalization and improved survival when PR follows COPD-related hospitalizations.[7] Rehabilitation may also contribute to reducing the cost of treatment for patients with COPD. Applied after hospitalization for a COPD exacerbation rehabilitation might result in net cost savings and improvements in QALE.[10]

It is worth noting that physical activity may influence the inflammatory process underlying COPD, potentially slowing the disease progression and reducing exacerbation risk. Inflammation is a primary host defence mechanism against long-term exposure to toxic gases or particulates. Disease development in COPD is driven by the interaction of several interrelated factors, including oxidative stress, inflammation, tissue damage and impaired tissue repair mechanisms. It is interesting to note that experimental preclinical studies show clear anti-inflammatory response of exercise training in smoke-exposed mice. In COPD patients, however, available data are inconsistent. Possible explanations for variability in immunomodulation by exercise training in COPD include: severity and phenotype of COPD, variation in baseline inflammatory state; baseline fitness and/or variability in response of fitness to training; and types, intensity, frequency and duration of exercise training. Endurance exercise training benefits all severities of COPD in terms of increased exercise endurance and reductions in dyspnoea, however it seems that some patients may gain greater immunomodulatory benefits than others.[11]

Another important complication of COPD that can be effectively addressed through physical activity is skeletal muscle dysfunction (SMD). It is a common and significant problem in COPD and is characterised by skeletal muscle mitochondrial damage, muscle atrophy, and impaired activation of myosatellite cells, leading to reduced muscle strength and endurance, affecting the patient's quality of life and prognosis. The reason is abnormal expression levels of myokines in COPD patients, which in turn disrupt skeletal muscle mitochondrial function, inhibit regenerative capacity, and promote muscle atrophy. Exercise and modulation of myokines through exogenous supplementation or knockdown have significant potential in the prevention and treatment of SMD in COPD. Physical activity modulates the expression levels of myokines and is a much simpler and less expensive solution to implement than other mentioned interventions. A process depends on factors such as exercise type, exercise duration, and exercise intensity. Notably, long-term (≥8 weeks) combined resistance and endurance training of moderate-to-high intensity has a pronounced effect on increasing the levels of IGF-1 and irisin in COPD skeletal muscle, promoting muscle hypertrophy and improving muscle strength and function.[12]

4. **Self-management and education**

The aim of self-management interventions is to motivate, engage and coach patients to positively adapt their health behaviors and develop skills to better manage their COPD on a day-to-day basis. Enhancing patient knowledge is an important first step towards behavior change, but information and advice alone are insufficient for promoting self-management skills. Personalized education and training that considers specific issues relating to the individual patients, and that aims to enhance long-term functionality and appropriate health behaviors, is likely to benefit patients more. Education sessions can be individual and in group. During group sessions, patients engage in active learning of programme content. During one-on-one interactions, a motivational communication style should be used to encourage patients to take greater responsibility for their health and wellbeing.[3]

5. **Participants selection**

2026 GOLD Report recommends patients with high symptom burden and risk of exacerbations to be encouraged to take part in a formal rehabilitation programme that includes setting patient goals and is designed and delivered in a structured manner, taking into account the individual's COPD characteristics, including extra-pulmonary features such as skeletal muscle dysfunction and exercise intolerance, and comorbidities.[3] National Institute for

Health and Care Excellence states that PR is not suitable for people with unstable cardiac disease, locomotor or neurological difficulties precluding exercise such as severe arthritis or peripheral vascular disease, and people in a terminal phase of an illness or with significant cognitive or psychiatric impairment.[6]

6. Duration of rehabilitation programme

When planning a rehabilitation programme, it is important to be aware that its duration does not have a significant impact on the outcome.[13] 2026 GOLD Report recommends programmes to last 6 to 8 weeks as the most optimal. Extending PR to 12 weeks does not achieve additional benefits. Supervised exercise training at least twice weekly is recommended. This can include any regimen from endurance training, interval training, resistance/strength training. Training programme should include upper and lower limbs as well as walking exercise. Other rehabilitation propositions include flexibility, inspiratory muscle training and neuromuscular electrical stimulation. The content, scope, frequency, and intensity of rehabilitation intervention should be individualized. Clinically significant improvements in physical activity are observed when a centre based PR programme is complemented with a physical activity promotion programme. The patient should be educated about the importance of long-term behavior change to improve physical functionality, and reduce the psychological impact of COPD.[3]

7. Assessment

A comprehensive assessment prior to the prescription of a dedicated rehabilitation programme addressing the pulmonary and nonpulmonary physiological problems, as well as mental, motivational and social ones is a crucial element of rehabilitation. Based on the assessment, an individualised programme can be designed, taking into account the patient's specific needs and preferences. In addition, it is necessary to plan a follow-up pathway once the initial programme has been completed. Patients who are able to continue some form of ongoing exercise training as part of long-term disease management tend to achieve significantly better outcomes. Such a maintenance programme completes the PR process.[2] Baseline and outcome assessments allow to specify individual maladaptive behaviors, physical and mental health impediments to training, goals, barriers and capabilities and to determine gains and to target areas for improvement. Assessments should include detailed history, physical examination, post-bronchodilator spirometry, assessment of functional exercise capacity, measurement of health status and impact of breathlessness and fatigue, assessment of

inspiratory and expiratory muscle strength and lower limb strength in patients who suffer from muscle wasting and discussion about individual patient goals, problematic activities of daily living, and expectations and knowledge about the disease. There are several questionnaires developed for patients with respiratory diseases, such as the CAAT™, CRQ, and SGRQ. The HADS and the PRIME-MD patient questionnaire can be used to improve identification and treatment of anxious and depressed patients. Exercise capacity can be assessed by a few methods. One of possibilities is cycle ergometry or treadmill exercise with the measurement of maximum oxygen consumption, maximum heart rate, and maximum work performed. In clinical practice standardized self-paced, timed walking tests, e.g. 6MWD, are useful as they require minimal facilities and are relevant to routine functioning. Compared with treadmill tests, shuttle walking tests are simpler to perform and provide more comprehensive data than entirely self-paced assessments. At least one practice session is required for walking tests before the data can be interpreted.[3]

8. Exercise training

Patients with COPD often have other medical conditions such as heart disease, osteoporosis, musculoskeletal disorders, lung cancer, depression and anxiety.[4] Comorbidities influence patients' clinical condition and prognosis and require treatment. They can also mimic and/or aggravate an acute exacerbation.[3] It is crucial that, when deciding on rehabilitation, the patient's clinical condition is taken into account. Training should be individualized, appropriate for disease severity, comorbidities, and physical capability, with a focus on gradual progression in intensity and duration. Patients with more severe disease must be supervised to ensure safety during exercise.[14] At the same time, it is worth noting that exercise training might be the most beneficial for patients in severe stage of COPD in improving exercise capacity through endurance training and psychological status through resistance training.[15] Exercise-based PR can also reduce dyspnoea of this group of patients. Patients with very severe but stable COPD should perform continuous training exercise mode.[16] The combination of exercise and medication is an effective method of severe COPD management. Moreover, American Thoracic Society recommends PR after hospitalization for an exacerbation of COPD.[17]

Moderate intensity aerobic exercise, resistance training, and high intensity interval training are the most common forms of PR exercises. They were observed to improve exercise capacity, reduce dyspnoea, and enhance quality of life.[14] New forms of exercise, e.g. tai chi, yoga, aquatic exercise, and whole-body vibration training, are included in the

development of individualized PR exercise programmes. It should be recognised that some patients may not respond adequately or respond inconsistently to specific training programmes.[18]

The aerobic capacity is typically measured as VO2max, which is commonly used as an indicator of cardiorespiratory fitness. Endurance exercise has the greatest impact on VO2max.[19] Endurance training can improve patients' motor function and reduce dyspnoea.[20] In some studies, aerobic training demonstrates more evident effectiveness than resistance training,[13] however it should be noted that combined aerobic and resistance training is suggested over aerobic training alone.[21] The study comparing the effects of endurance training and resistance training found no significant difference between the two exercise regimens when added to standard medication in improving quality of life, dyspnoea, psychological state, or lung function among patients with stable COPD. However, endurance training exhibited a slight advantage over resistance training on exercise capacity at the 12-month follow-up.[15] In another study comparing three different training modalities in patients with COPD, strength training alone increases maximal exercise capacity to a similar extent as endurance exercise and combined exercise, but with a significant increase in muscular strength. The greatest improvement of quality of life is observed in the combined training.[19]

9. Interventions improving ventilation

Isolated inspiratory muscle training (IMT) effectively improves inspiratory muscle strength, functional capacity, and pulmonary function in patients with COPD. The results of studies on the effectiveness of relieving dyspnoea and improving quality of life are inconsistent. [22,23] Additional interventions might improve effectiveness of IMT. In one of the studies patients receiving IMT with manual therapy showed improved FEV1 and FVC values, improved functional capacity, increased respiratory muscle strength, improved pulmonary function, reduced dyspnoea and fatigue perception, and improved quality of life compared with patients treated with IMT alone.[24] Recently the interest in IMT has increased due to the development of different mechanical devices that help both in programmes with direct supervision, as well as in others controlled by remote monitoring, e.g. AirOFit PRO™, PowerBreathe®, or FeelBreathe®. In addition, FeelBreathe® has a special nasal device. The device favours a more physiological breathing, and it also allows its use in dynamic situations, thereby making it potentially useful during exercise.[25]

Other exercises that can be applied for patients with COPD are progressive muscle relaxation (PMR) and deep breathing (DB) exercises. In a study PMR exercises applied once a week and the 10-minute DB exercises applied 3 times a day every day, caused a significant improvement of the dyspnoea and fatigue. Moreover, it was effective on FEV1/FVC values.[26]

Exercises may also improve the effectiveness of inhaled pharmacotherapy, a crucial part of treatment. Pursed-lip breathing exercise and inhaler training improves breathing exercise and inhaler using skills, reduces the negative effects of COPD on the individual, relieves the severity of dyspnoea, and improves the quality of life.[27] Other exercises improving ventilation include voice facilitation and diaphragmatic breathing exercise. Singing exercise mostly improves quality of life. The effects breathing exercises vary significantly between their types as well as between outcome measures.[28]

Respiratory support interventions, including noninvasive positive pressure ventilation, high flow nasal cannula oxygen therapy and oxygen administered through nasal cannulas or face masks during exercise, can enhance exercise capacity and tolerance.[29] Supplemental oxygen, considering a higher concentration or flow rate, might be specifically prescribed for certain responding patients and in specific clinical conditions, when high intensity training is desired and not contraindicated.[30]

10. **Balance training**

Another challenge experienced by patients with COPD that might be managed with exercises is balance. People with COPD have a clinically meaningful balance reduction, which may be related to reduced muscle strength, physical activity and exercise capacity.[31] In a study in which an 8-week home based balance PR programme was introduced to individuals with COPD observed results included improving balance performance, reducing risk of falls, and improving health related quality of life. The programme consisted of breathing, stretching, endurance exercises, education and balance training which included stance exercises with different bases of support and surfaces, walking and functional exercises.[32] IMT might be an effective addition to the balance training. IMT associated with whole-body endurance training significantly improves functional balance. It suggests that inspiratory muscle training combined with endurance training is more effective in improving inspiratory muscle function and generating a better balance control than endurance training alone.[33]

11. Overcoming limitations

Home based IMT might be a solution for patients with COPD who face barriers in accessing traditional PR programmes. IMT exercises performed stand-alone demonstrated significant gains in inspiratory muscle strength, inspiratory muscle work and endurance, as well as in functional exercise capacity.[34]

Another possibility for COPD patient without access to centre based rehabilitation is telerehabilitation. It is a new form of rehabilitation created as a response to the COVID-19 pandemic. Telerehabilitation is effectively improving stress tolerance and symptom control in COPD patients. It was observed to be equally effective as centre based PR.[35] Therefore COPD patients can be offered the choice of a centre based PR or telerehabilitation. In most cases telerehabilitation still involves a face-to-face, centre based assessment to complete a comprehensive pre-rehabilitation evaluation. It should be recognised that, given the shortage of trained healthcare professionals and the growing appeal of technology, efforts should be made to ensure that telerehabilitation is implemented appropriately and not misused.[3]

An alternative approach is home based PR. This form of rehabilitation appears to be equally safe as outpatient PR. Outcomes of home based PR are also similar to standard PR.[36]

Both forms of rehabilitation have the potential to become an alternative for centre based PR. A study was conducted to compare a Long-Term Telerehabilitation and an Unsupervised Training at Home patients with COPD. Patients were assigned to three groups and followed up for 2 years. Patients in telerehabilitation group received individualized treadmill training at home supervised by a physiotherapist and self-management, while the unsupervised training group performed unsupervised treadmill exercise at home. Before starting long-term training, both groups had undergone a supervised in-person training session on the treadmill with an experienced physiotherapist and had received personalised training programme. Patients in the control group received standard care. The final results showed a positive influence of both interventions. Patients in telerehabilitation and unsupervised training groups required fewer hospitalizations and emergency department presentations than patients in the control group. Moreover, telerehabilitation and unsupervised training groups health status for 1 year was better. In both these groups patients reached and maintained significant improvements in exercise capacity. These findings lead to conclusion that long-term telerehabilitation or unsupervised exercise training at home can potentially improve the availability of PR for patients living in remote areas and with no access to centre based exercise programmes.[37]

Equipment can also be a limitation for a patient. The gymnasium equipment, e.g. treadmills, leg or arm cycle ergometers, rowing machines, weight machines, is a useful tool in training,

however not available for all patients. In rural and remote areas and in developing countries where the access to gymnasium equipment is limited PR programmes using minimal equipment may be a suitable, less expensive alternative. PR programmes using minimal equipment include ground walking and Nordic walking for aerobic training, hand weights, body weight resistance exercises and elastic resistance band exercises for resistance training. This type of training achieves significant improvements in 6MWD and HRQoL and is comparable with exercise equipment–based programmes for improving 6MWD and strength.[38] Minimal equipment training provides similar effects on muscle strength and exercise capacity to centre based programmes.[21] Common application of programmes using minimal equipment would enable delivery of PR to a greater number of people with COPD.

12. Conclusions

PR is an important and effective element of COPD treatment. It is based on a holistic approach and requires a multidisciplinary team. Personalised programme results in the best therapeutic outcome. Appropriate intervention can improve patient's condition, symptoms and life quality as well as reduce the number of exacerbations. New forms of PR help to overcome the limitations in access to PR and may increase patient participation.

Disclosure

Author contributions

Conceptualization: Maria Jędryka, Wiktoria Kolasa
Methodology: Maria Jędryka, Olga Kowalczyk
Software: Bożena Kiełbasa, Marta Kaczorek
Formal analysis: Aleksandra Stadnik, Monika Lis
Investigation: Monika Lis, Julia Gatniejewska
Resources: Aleksandra Stadnik, Wiktoria Kolasa
Writing-rough preparation: Bożena Kiełbasa, Maria Jędryka
Writing – review and editing: Katarzyna Pagacz, Julia Gatniejewska
Visualization: Katarzyna Pagacz, Marta Kaczorek
Supervision: Wiktoria Kolasa, Maria Jędryka
Project administration: Olga Kowalczyk

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Conflict of Interest

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Declaration of the use of generative AI and AI-assisted technologies in the writing process

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