Types of Exercises Required in a Pulmonary Rehabilitation Program: A Review of the Literature

Irmawan Andri Nugroho[1,2], Fatimah Ahmedy[3], Zulkhairul Naim bin Sidek Ahmad[4]

[1]*PhD Student in Nursing, Faculty of Medicine and Health Sciences, Universiti Malaysia Sabah, Kota Kinabalu, Malaysia. ,*
[2]*Department of Nursing, Faculty of Health Sciences, University of Muhammadiyah Gombong, Kebumen, Indonesia.*
[3]*Sabah Rehabilitation Research & Service Group, Faculty of Medicine & Health Sciences, Universiti Malaysia Sabah, Kota Kinabalu, Malaysia.*
[5]*Department of Medical Education, Faculty of Medicine and Health Sciences, Universiti Malaysia Sabah, Kota Kinabalu, Malaysia. Email: fatimahmedy@ums.edu.my*

KEYWORDS

Chronic Obstructive Pulmonary Disease, Pulmonary Rehabilitation, Exercise

ABSTRACT:

Introduction: Chronic Obstructive Pulmonary Disease (COPD) is a chronic respiratory condition that can be prevented and treated. It is identified by persistent airflow limitation. It is generally caused by extended exposure to hazardous particles, particularly those emitted by smoking, pollution, and occupational risks, and is a primary cause of morbidity and mortality globally. Aerobic, resistance, flexibility, and inspiratory muscle training (IMT), as well as high-intensity interval training (HIIT), are all necessary for enhancing functional capacity and quality of life in COPD patients. To enhance the effects of these exercise treatments, more research and optimization are required.

Objectives: The purpose of this study is to determine the impact of various exercise therapies within pulmonary rehabilitation programs on health outcomes and quality of life in COPD patients.

Methods: A literature review was conducted using ScienceDirect and other databases, focusing on randomized controlled trials involving pulmonary rehabilitation for COPD published in English from 2015 to 2024. Search terms included 'pulmonary rehabilitation' and 'COPD.' Eligible studies included trials assessing exercise interventions in PR, excluding review articles, case studies, and dissertations. Data extracted included study details, participant demographics, interventions, and outcomes.

Results: Aerobic and resistance activities are important components of PR, as they significantly improve cardiovascular health, endurance, and muscle strength. HIIT was demonstrated to benefit those with low exercise tolerance, while IMT efficiently strengthened respiratory muscles, lowering dyspnea and improving overall breathing efficiency. Flexibility exercise improved posture and movement, hence contributing to general physical well-being.

Conclusions: PR programs, including aerobic, resistance, flexibility, and inspiratory muscle training, are crucial for managing COPD and improving patient outcomes. A tailored approach considering patient needs maximizes benefits.

1. Introduction

Chronic Obstructive Pulmonary Disease (COPD) is a preventable and treatable respiratory condition characterized by persistent airflow limitation and chronic respiratory symptoms. The disease is primarily caused by long-term exposure to harmful particles or gases, particularly from smoking, environmental pollutants, and occupational hazards. COPD manifests through a combination of small airway disease and parenchymal destruction, leading to progressive and often irreversible breathing difficulties (GOLD, 2024).

The prevalence of COPD continues to grow globally, with over 390 million people affected, making it one of the leading causes of morbidity and mortality worldwide (GOLD, 2024). According to the Global Initiative for Chronic Obstructive Lung Disease (GOLD) 2024 report, COPD is the third leading cause of death, responsible for approximately 3.23 million deaths annually. This burden is expected to rise due to an aging population, increased smoking rates in some regions, and

ongoing exposure to environmental risk factors, particularly in low- and middle-income countries (GOLD, 2024). The results of the Indonesian Ministry of Health's Basic Health Research showed the prevalence of COPD in Indonesia was 3.7 percent per population, while in Central Java it was 3.4 percent per population (Health Minstry Republik Indonesia, 2019).

Geographically, the prevalence of COPD varies significantly, with higher rates observed in regions where smoking rates and air pollution are more prevalent, such as Southeast Asia and parts of Africa. Although smoking remains the primary risk factor for COPD, non-smokers, particularly those exposed to biomass fuel smoke and air pollution, also exhibit a significant disease burden. Additionally, COPD disproportionately affects older adults, with prevalence and severity increasing with age (GOLD, 2024).

Despite advancements in diagnosis and treatment, COPD remains underdiagnosed and undertreated, particularly in low-resource settings. Early diagnosis, smoking cessation, and implementation of preventive measures are crucial in reducing the global impact of the disease (GOLD, 2024).

Pulmonary rehabilitation (PR) is an important component in the therapy of patients with chronic respiratory diseases, specifically chronic obstructive pulmonary disease (COPD). PR programs are designed to improve the functional capacity and quality of life in these patients through a combination of exercise training, education, and behavioral changes. The inclusion of various types of exercise, such as aerobic, resistance, and flexibility training, has been proven to significantly enhance both physical and psychological outcomes (Yohannes et al., 2022).

Aerobic exercise, such as walking or cycling, is essential in improving cardiorespiratory fitness, which leads to increased exercise tolerance and reduced symptoms of dyspnea. Resistance training focuses on enhancing muscle strength, particularly in the lower limbs, which is critical for improving functional mobility and reducing the risk of falls. In addition, flexibility and stretching exercises contribute to better posture and reduce the risk of injury (Andrews et al., 2015).

Current developments in pulmonary rehabilitation emphasize the importance of individualized exercise regimes that are adapted to each patient's individual abilities and limits. These programs frequently include high-intensity interval training (HIIT), which has been shown to have significant benefits in people with limited exercise tolerance. Furthermore, inspiratory muscle training is becoming popular as a complementary treatment for improving respiratory muscle function and reducing dyspnea (Wuyts et al., 2024).

Despite the substantial evidence supporting the effectiveness of exercise-based therapies, there is still a need to develop and regulate the components of PR programs to optimize outcomes (Amin et al., 2022). The purpose of this research is to explore the various types of exercises that are necessary for pulmonary rehabilitation and how these interventions support to improving health as well as quality of life in patients with chronic obstructive pulmonary disease.

2. Methods

2.1 Study design

The study was designed as a literature review, with a systematic search of articles and a comprehensive review of the existing relevant literature that fulfilled the eligibility criteria.

2.2 Search methodology

The researcher conducted a literature search through Science Direct using the following search terms: 'pulmonary rehabilitation' AND 'COPD'. To verify that all of the research chosen was completed the standard publication protocols, several search databases were chosen as information sources. Additional manual searches were conducted using the references identified in the chosen publications.

2.3 Study selection

All of the selected articles were published in English. Randomized controlled trials of pulmonary rehabilitation with COPD patients were conducted between 2015 and 2024. Review papers, case studies, and dissertations were all excluded.

2.4 Data extraction and recording

The following data was collected and documented: (i) article details (title, author, year of publication, study design, and sample size); (ii) study participants' demographic and clinical characteristics; and (iii) study outcomes (research variables, interventions, and outcome measures). Ethical approval was not requested because the review was based existing publications.

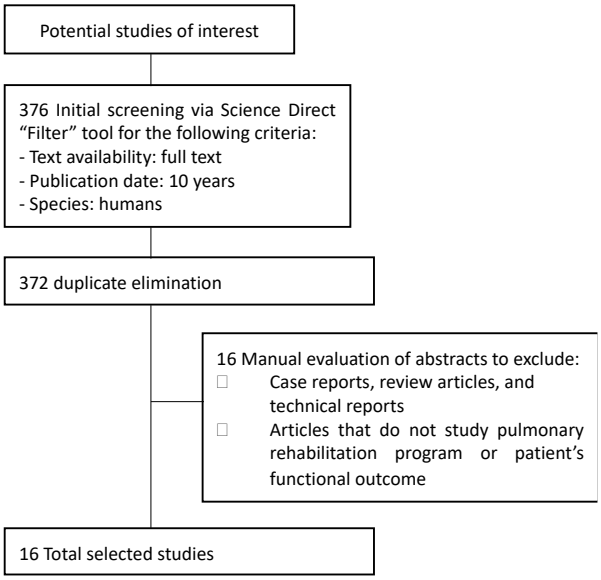

Fig. 1. Flowchart of articles selection.

Authors	Year	Title	Journal	Subjects	Intervention	Result
Anderson José, Anne E. Holland, Cristiane S. de Oliveira, Jessyca P.R. Selman, Rejane A.S. de Castro, Rodrigo A. Athanazio, Samia Z. Rached, Alberto Cukie, Rafael Stelmach, Simone Dal Corsoa (José et al., 2017)	2017	Does home-based pulmonary rehabilitation improve functional capacity, peripheral muscle strength and quality of life in patients with bronchiectasis compared to standard care?	Brazilian Journal of Physical Therapy	48 adult patients with bronchiectasis	8 months pulmonary rehabilitation program with resistance training carried out using an elastic band for the following muscles: quadriceps, hamstrings, deltoids, and biceps brachii	Clinical trial protocol
Gudula J.A.M.Boon, Steffi M.J. Janssen, Stefano Barco, Harm Jan Bogaard, Waleed Ghanima, Lucia J.M. Kroft, , Lilian J Meijboom, Maarten K Ninaber, Esther J. Nossent, Martijn A Spruit, Petr Symersky, Hubert W Vliegen, Anton Vonk Noordegraaf, Menno V. Huisman, Bob Siegerink, Jannie J Abbink, Frederikus A Klok. (Boon et al., 2021)	2021	Efficacy and safety of a 12-week outpatient pulmonary rehabilitation program in Post-PE Syndrome	Thrombosis Research	56 post-pulmonary embolism patients	12-week pulmonary rehabilitation, twice weekly	Improved PE-specific quality of life, fatigue, and functional status (Post-VTE Functional Status Scale) in 67% of patients, with a significant increase in training intensity and PEmb-QoL score
Abebaw M Yohannes, Richard Casaburi, Sheila Dryden, Nicola A. Hanania, (Yohannes et al., 2022)	2022	The effectiveness of pulmonary rehabilitation on chronic obstructive pulmonary disease patients with concurrent presence of comorbid depression and anxiety	Respiratory Medicine	734 patients with clinically stable COPD (Mean age: 71 years; 51% men)	8-week outpatient multidisciplinary pulmonary rehabilitation (PR) consisting of 1 hour of exercise and 1 hour of education, 2 hours per week	PR is effective in addressing both the physical and psychological challenges faced by COPD patients with these comorbidities

Safia Ahmed, Neeraj Sharma, Seema Patrikar, Samiullah. (Ahmed et al., 2022)	2022	Efficacy of early structured pulmonary rehabilitation program in pulmonary function, exercise capacity, and health-related quality of life for patients with post-tubercular sequelae: A pilot study	Medical Journal Armed Forces India	62 patients with post-tuberculosis sequelae	12-week structured pulmonary rehab program	Statistically significant improvement in pulmonary function (FEV1, FVC), exercise capacity (6MWD), but no significant improvement in HRQoL compared to the control group
Revati Amin, G. Arun Maiya, Aswini Kumar Mohapatra, Vishak Acharya, Jennifer A. Alison, Marita Dale, K. Vaishali. (Amin et al., 2022)	2022	Effect of a home-based pulmonary rehabilitation program on functional capacity and health-related quality of life in people with interstitial lung disease – A randomized controlled trial protocol	Respiratory Medicine	96 COPD patients	Home-based intervention of the exercise program: (Exercise training booklet + weekly telephone follow-up).	A randomized controlled trial protocol
Vasileios Andrianopoulos, Rainer Gloeckl, Tessa Schneeberger, Inga Jarosch, Ioannis Vogiatzis, Emily Hume, Rembert A. Koczulla, Klaus Kenn. (Andrianopoulos et al., 2021)	2021	Benefits of pulmonary rehabilitation in COPD patients with mild cognitive impairment – A pilot study	Respiratory Medicine	60 COPD patients (42% with cognitive impairment)	Pulmonary rehabilitation (3-week program)	PR improved global cognitive function, health status, and exercise capacity, though less improvement in 6MWT for CI patients. CI patients improved less in emotional and bodily pain aspects.
Yara Al Chikhanie, Sébastien Bailly, Ines Amroussa, Daniel Veale, Frédéric Hérengt, Samuel Verges. (Al Chikhanie et al., 2022)	2022	Clustering of COPD patients and their response to pulmonary rehabilitation	Respiratory Medicine	835 COPD patients admitted to a PR centre	In-patient pulmonary rehabilitation	Identified homogeneous patient clusters with distinct responses to PR. Non-responders were older, more severe, had severe oxygen desaturation and dyspnea, and required long-term oxygen therapy.

Joshua A. Bishop, Lissa M. Spencer, Tiffany J. Dwyer, Zoe J. Mc Keough, Amanda McAnulty, Sonia Cheng, Jennifer A. Alison. (Bishop et al., 2024)	2024	Patterns of physical activity of people with COPD during participation in a pulmonary rehabilitation program	Respiratory Medicine	29 COPD patients	PR program twice weekly for 60–90 min (allowing for rests), for 8 to 12 weeks. The PR program consisted of walking (overground and treadmill), cycling and upper and lower body resistance training.	Daily step count and time spent in MVPA increased significantly during the PR week, solely due to increased PA on days participants attended PR.
Atsuyoshi Kawagoshi, Noritaka Kiyokawa, Keiyu Sugawara, Hitomi Takahashi, Shunichi Sakata, Masahiro Satake, Takanobu Shioya. (Kawagoshi et al., 2015)	2015	Effects of low-intensity exercise and home-based pulmonary rehabilitation with pedometer feedback on physical activity in elderly patients with chronic obstructive pulmonary disease	Respiratory Medicine	27 elderly patients with COPD (mean age 74)	Low-intensity, home-based PR; Group PR only or PR + P (with pedometer feedback)	The PR + P group showed significantly greater increases in daily walking time (51.3 ± 63.7 min/day) compared to the PR group (12.3 ± 25.5 min/day). Improvements in walking time correlated with gains in 6-min walking distance (6MWD) and quadriceps femoris (QF) strength across all patients.
María Jesús Prunera-Pardell, Susana Padín-López, Adolfo Domenech-del Rio, Ana Godoy-Ramírezc. (Prunera-Pardell et al., 2018)	2018	Effectiveness of a respiratory rehabilitation programme in patients with chronic obstructive pulmonary disease	Enfermería Clínica (English Edition)	105 COPD patients	8-weeks pulmonary rehabilitation program, Respiratory re-education techniques, Training technique to resistance of lower limbs, Upper limb training technique	A pulmonary rehabilitation programme for 8 weeks improved the exercise capacity, dyspnea and quality of life of patients with severe and very severe chronic obstructive pulmonary disease.
Sarah Gephine, St´ephanie Fry, Emilie Margoline, Alice Gicquello, C´ecile Chenivess, Jean-Marie Grosbois. (Gephine et al., 2023)	2023	Home-based pulmonary rehabilitation for adults with severe asthma exposed to psychosocial chronic stressors	Respiratory Medicine	111 adults with severe asthma	8-week home-based PR programme, consisting of a weekly supervised 90-min home session, during which education and self-management strategies and physical training	A large proportion of adults with severe asthma, mainly women, have been exposed to chronic stressors at the time of starting a PR programme, resulting in higher anxiety symptoms and hyperventilation symptoms.
M. Spielmanns, R. Gloeckl, C. Schmoor, W. Windisch, J.H. Storre, M. Boensch, and K. Kenn. (Spielmanns et al., 2016)	2016	Effects on pulmonary rehabilitation in patients with COPD or ILD: A retrospective analysis of clinical and functional	Respiratory Medicine	1,492 COPD patients and 599 ILD patients	Inpatient Pulmonary Rehabilitation (PR)	In COPD group: 30% non-responders to physical improvement; non-responders had higher initial 6MWD. In ILD group: 37% of females and 43% of males were non-responders, with higher initial 6MWD in this

		predictors with particular emphasis on gender			group as well. PR benefits those with the greatest limitations most.
Leanne Andrews, Ruth Barlow, and Izzie Easton. (Andrews et al., 2015)	2015	Differences in patient outcomes between a 6, 7y and 8 week pulmonary rehabilitation programme: A service evaluation	Physiotherap	363 patients with chronic respiratory conditions	Pulmonary rehabilitation twice a week for 6, 7, or 8 weeks	8-week program yielded the greatest improvement in exercise capacity (ISWT). Improvement was observed in all durations; ISWT improvements were obtained across all three programs
Pasquale Ambrosino, Di Minno, D'Anna Matteo Nicola Dario, Formisano Silvestro Ennio, Pappone Roberto, Mancusi Nicola, Molino Costantino, Motta Antonio, Maniscalco Andrea, Mauro. (Ambrosino et al., 2023)	2023	Pulmonary rehabilitation and endothelial function in patients with chronic obstructive pulmonary disease: A prospective cohort study	European Journal of Internal Medicine	40 severe COPD patients (67.5% male, median age 72.5 years)	Pulmonary rehabilitation of	Significant improvement in functional parameters, exercise capacity, disability, and quality of life. FMD changes were positively correlated with FEV1 improvements, both in absolute values and as percentages of predicted values, suggesting PR may benefit endothelial function and reduce cardiovascular risk in COPD.
Anne-Cecile Berriet, Marc Beaumont, Loïc Peran, Catherine Le Ber, Francis Couturaud. (Berriet et al., 2022)	2022	Effects of pulmonary rehabilitation on fear of falling in Chronic Obstructive Pulmonary Disease (COPD) patients: An observational study	Respiratory Medicine and Research	80 COPD patients	4-weeks pulmonary rehabilitation program, 5 days per week.	a significant decrease of fear of falling in COPD patients after PRP, correlated with improvement of QOL, balance and decrease of dyspnea.
Annemieke Fastenau, Onno CP. van Schayck, Bjorn Winkens, Karin Aretz, Rik Gosselink, Jean WM Muris. (Fastenau et al., 2020)	2020	Effectiveness of an exercise training programme COPD in primary care: A randomized controlled trial	Respiratory Medicine	90 patients with mild to moderate COPD	4-month exercise training program	The exercise training program was effective in improving physical fitness measures, specifically exercise capacity and muscle strength, but did not significantly impact breathlessness, quality of life, or daily physical activity in patients with mild to moderate COPD.

(Source: Authors)

3. Results

Management of chronic respiratory conditions, including chronic obstructive pulmonary disease (COPD), depends on pulmonary rehabilitation (PR) programs which help to improve people's overall quality of life. Overcoming the resistance found in concrete is main purpose given such purposes, all exercise types can be combined tailored to enhance patient physical capabilities and overall health. Exercise training is a centrally important part of these programs. Different types of training, such as aerobic, strength and stretching for example, have different aims and physiological advantages depending upon how they are conducted in combination (Amin et al., 2022).

Aerobic exercise is important in PR because it increases cardiovascular capacity and reduces symptoms such as dyspnea. Walking, cycling, and treadmill exercise are common exercises aimed at improving endurance and general exercise tolerance in patients with restricted lung capacity. This type of exercise has been demonstrated to improve oxygen uptake while reducing the perceived effort during physical activity (Kawagoshi et al., 2015).

Resistance training emphasizes muscle strength, which is important maintaining functional independence, particularly in the lower limbs. Weight machine, resistance band, and body-weight workouts target important muscle groups to combat the muscle weakening common in COPD patients. According study findings, resistance training may prevent hospitalizations by enhancing patients' ability to conduct daily activities (Puhan et al., 2021).

Flexibility and stretching exercises are provided to increase range of motion and reduce stiffness, which can help prevent injuries and improve postural alignment. Stretching exercises, particularly for the chest and upper body, are frequently recommended to assist maintain an open, functioning posture that is excellent for respiratory mechanics (Kawagoshi et al., 2015).

Inspiratory muscle training (IMT) is also an important part of PR programs. IMT employs devices that provide resistance during inhalation, thereby strengthening the diaphragm and other respiratory muscles, resulting in enhanced breathing efficiency and reduced dyspnea. According to studies, IMT can be especially effective in improving exercise tolerance in people with severe airflow limitations (Kawagoshi et al., 2015).

High-Intensity Interval Training (HIIT) is an innovative exercise that provides significant physical advantages in a shorter period of time than regular exercise. HIIT combines brief bursts of intensive activity with periods of rest or low-intensity activity, which can improve exercise tolerance and cardiovascular fitness in people who cannot tolerate long-duration exercises (Spruit et al., 2022).

These exercise modalities serve as base elements for PR programs, addressing the different physical and functional needs of individuals with chronic respiratory diseases (Valencia et al., 2023). To optimize the benefits of pulmonary rehabilitation, customized methods is required, taking into account each patient's specific limitations and capabilities (Meneses-Echavez et al., 2023).

4. Discussion

A comprehensive pulmonary rehabilitation (PR) program involves a variety of exercise types aimed at repairing the physical and respiratory limitations experienced by individuals with chronic lung diseases, such as chronic obstructive pulmonary disease

(COPD). While aerobic, resistance, flexibility, inspiratory muscle training (IMT), and high-intensity interval training (HIIT) are common exercise therapies, the degree to which each contributes to overall improvement varies, emphasizing the importance of individualized PR approaches (GOLD, 2024).

Aerobic exercise is still an important component of PR programs due to its proven benefits in increasing cardiovascular health, endurance, and reducing dyspnea. Aerobic exercises, like as walking or cycling, which are frequently considered as an essential component of PR, have been proven to reduce dyspnea and fatigue, two main barriers to physical activity in COPD patients (Berriet et al., 2022). According to studies, improvements in oxygen uptake during aerobic exercise can reduce some restrictions of physical activity in COPD patients, while more study is needed to determine the particular intensities and durations most effective for different stages of COPD (Ramos et al., 2021).

Resistance training is widely acknowledged as important in PR for resolving muscle weakness, particularly in the lower limbs, which is common in COPD patients due to physical inactivity and systemic inflammation. This type of exercise is essential for retaining independence in daily activities because muscle strength correlates highly with functional outcome for this population. Resistance training not only improves physical strength, but it also correlates with decreased healthcare utilization and hospitalizations, showing that it could be cost-effective in PR programs (José et al., 2017).

Inspiratory muscle training (IMT) aims to enhance dyspnea and quality of life by strengthening the diaphragm and other respiratory muscles. IMT has been proven to be helpful in improving inspiratory muscle strength, which can directly improve exercise tolerance by reducing work of breathing in COPD patients. However, disagreements over its inclusion as a standard procedure in PR proceed, as patient response to IMT may vary depending on illness severity, stressing the need for additional study to identify those who may benefit the most from IMT (José et al., 2017).

Flexibility and stretching exercises are regarded as beneficial yet essential elements of PR. Flexibility exercise may improve posture and make breathing easier by increasing chest wall movement. According to studies, these exercises may help prevent musculoskeletal issues and improve patient comfort during physical activities, making them an important, while secondary, component of PR (Bishop et al., 2024).

High-Intensity Interval Training (HIIT) has become popular as an alternative to standard endurance training. HIIT, which consists of short bursts of intensive exercise followed by rest periods, may be especially beneficial for people who cannot tolerate long-duration exercises. Although HIIT has shown encouraging effects in terms of cardiovascular health and exercise tolerance, its suitability for all PR patients is insufficient, as some may struggle with its intensity. According to studies, HIIT can be an efficient complement in the advanced stages of PR when customized to patient capabilities (Wang et al., 2023).

According to studies, 8-week respiratory rehabilitation program with personalized attention and self-care education improves the exercise capacity and quality of life of severe and very severe COPD patients ($p<0.01$). However, it appears that their respiratory capacity (FEV1%) is not improving. These

benefits increase dramatically in post-RR and persist one year after the research, albeit in a decreased form. We believe that the reduction is attributable to the patients no longer devoting as much time to regular exercise or the quantity of exercises they conducted daily (Prunera-Pardell et al., 2018).

Overall, evidence supports the use of a multimodal exercise approach in PR, with customized procedures that allow patients to optimize their benefits in the cardiovascular, muscular, and respiratory aspects. As research progresses, developing these exercise routines to accommodate patient-specific needs depending on severity, comorbidities, and response to various exercise types will be essential to improving PR outcomes (Andrianopoulos et al., 2021). Future research should look into the comparative efficacy of these modalities and identify specific patient types who may benefit the most from specific combinations of PR exercises.

5. Conclusions

In conclusion, pulmonary rehabilitation (PR) is essential in managing chronic respiratory diseases such as COPD, with exercise training serving as an essential element in improving physical function and quality of life. Various exercise techniques, including as aerobics, resistance, flexibility, inspiratory muscle training (IMT), and high-intensity interval training (HIIT), each provide particular benefits that suit the diverse needs of PR patients. Aerobic and resistance training are primary exercises that focus on cardiovascular health and muscle strength, respectively, and are essential for improving exercise tolerance and functional independence. Meanwhile, IMT and flexibility exercises complement these main types of training by increasing respiratory muscle strength and range of motion, resulting in better breathing mechanics and general comfort during physical activity.

Finally, a personalized, holistic approach to PR becomes essential because it allows healthcare providers to personalize programs to specific patient needs based on disease severity, comorbidities, and personal response to exercise. Such customisation in PR procedures is predicted to increase patient adherence, maximize health benefits, and lower healthcare costs by reducing exacerbations and hospitalizations. Continued research into customized PR techniques and exercise efficacy will improve the effectiveness of PR programs, providing hope for better long-term outcomes in those with chronic pulmonary disease (Valencia et al., 2023).

References

[1] Ahmed, S., Sharma, N., Patrikar, S., & Samiullah. (2022). Efficacy of early structured pulmonary rehabilitation program in pulmonary function, exercise capacity, and health-related quality of life for patients with post-tubercular sequelae: A pilot study. *Medical Journal Armed Forces India*, *78*(2), 164–169. https://doi.org/10.1016/j.mjafi.2020.09.001

[2] Al Chikhanie, Y., Bailly, S., Amroussa, I., Veale, D., Hérengt, F., & Verges, S. (2022). Clustering of COPD patients and their response to pulmonary rehabilitation. *Respiratory Medicine*, *198*(May), 1–6. https://doi.org/10.1016/j.rmed.2022.106861

[3] Ambrosino, P., Di Minno, M. N. D., D'Anna, S. E., Formisano, R., Pappone, N., Mancusi, C., Molino, A., Motta, A., & Maniscalco, M. (2023). Pulmonary rehabilitation and endothelial function in patients with chronic obstructive pulmonary disease: A prospective cohort study. *European Journal of Internal Medicine*, *116*(February), 96–105. https://doi.org/10.1016/j.ejim.2023.06.015

[4] Amin, R., Maiya, G. A., Mohapatra, A. K., Acharya, V., Alison, J. A., Dale, M., & Vaishali, K. (2022). Effect of a home-based pulmonary rehabilitation program on functional capacity and health-related quality of life in people with interstitial lung disease – A randomized controlled trial protocol. *Respiratory Medicine*, *201*, 106927. https://doi.org/10.1016/J.RMED.2022.106927

[5] Andrews, L., Barlow, R., & Easton, I. (2015). Differences in patient outcomes between a 6, 7 and 8 week pulmonary rehabilitation programme: A service evaluation. *Physiotherapy (United Kingdom)*, *101*(1), 62–68. https://doi.org/10.1016/j.physio.2014.04.002

[6] Andrianopoulos, V., Gloeckl, R., Schneeberger, T., Jarosch, I., Vogiatzis, I., Hume, E., Koczulla, R. A., &

Kenn, K. (2021). Benefits of pulmonary rehabilitation in COPD patients with mild cognitive impairment – A pilot study. *Respiratory Medicine*, *185*(May), 106478. https://doi.org/10.1016/j.rmed.2021.106478

[7] Berriet, A. C., Beaumont, M., Peran, L., Le Ber, C., & Couturaud, F. (2022). Effects of pulmonary rehabilitation on fear of falling in Chronic Obstructive Pulmonary Disease (COPD) patients: An observational study. *Respiratory Medicine and Research*, *82*(august 2019), 2–7. https://doi.org/10.1016/j.resmer.2022.100932

[8] Bishop, J. A., Spencer, L. M., Dwyer, T. J., McKeough, Z. J., McAnulty, A., Cheng, S., & Alison, J. A. (2024). Patterns of physical activity of people with COPD during participation in a pulmonary rehabilitation program. *Respiratory Medicine*, *231*(July), 107724. https://doi.org/10.1016/j.rmed.2024.107724

[9] Boon, G. J. A. M., Janssen, S. M. J., Barco, S., Bogaard, H. J., Ghanima, W., Kroft, L. J. M., Meijboom, L. J., Ninaber, M. K., Nossent, E. J., Spruit, M. A., Symersky, P., Vliegen, H. W., Noordegraaf, A. V., Huisman, M. V., Siegerink, B., Abbink, J. J., & Klok, F. A. (2021). Efficacy and safety of a 12-week outpatient pulmonary rehabilitation program in Post-PE Syndrome. *Thrombosis Research*, *206*(August), 66–75. https://doi.org/10.1016/j.thromres.2021.08.012

[10] Fastenau, A., van Schayck, O. C., Winkens, B., Aretz, K., Gosselink, R., & Muris, J. W. (2020). Effectiveness of an exercise training programme COPD in primary care: A randomized controlled trial. *Respiratory Medicine*, *165*(January), 105943. https://doi.org/10.1016/j.rmed.2020.105943

[11] Gephine, S., Fry, S., Margoline, E., Gicquello, A., Chenivesse, C., & Grosbois, J. M. (2023). Home-based pulmonary rehabilitation for adults with severe asthma exposed to psychosocial chronic stressors. *Respiratory Medicine*, *217*(July). https://doi.org/10.1016/j.rmed.2023.107349

[12] GOLD. (2024). *Global Initiative for Chronic Obstructive Lung Disease* (pp. 15–47). https://goldcopd.org/2024-gold-report/

[13] Health Minstry Republik Indonesia. (2019). *Laporan Riskesdas 2018 Nasional.pdf* (p. 674).

[14] José, A., Holland, A. E., Oliveira, C. S. d., Selman, J. P. R., Castro, R. A. S. d., Athanazio, R. A., Rached, S. Z., Cukier, A., Stelmach, R., & Corso, S. D. (2017). Does home-based pulmonary rehabilitation improve functional capacity, peripheral muscle strength and quality of life in patients with bronchiectasis compared to standard care? *Brazilian Journal of Physical Therapy*, *21*(6), 473–480. https://doi.org/10.1016/j.bjpt.2017.06.021

[15] Kawagoshi, A., Kiyokawa, N., Sugawara, K., Takahashi, H., Sakata, S., Satake, M., & Shioya, T. (2015). Effects of low-intensity exercise and home-based pulmonary rehabilitation with pedometer feedback on physical activity in elderly patients with chronic obstructive pulmonary disease. *Respiratory Medicine*, *109*(3), 364–371. https://doi.org/10.1016/j.rmed.2015.01.008

[16] Meneses-Echavez, J. F., Chavez Guapo, N., Loaiza-Betancur, A. F., Machado, A., & Bidonde, J. (2023). Pulmonary rehabilitation for acute exacerbations of COPD: A systematic review. *Respiratory Medicine*, *219*(October). https://doi.org/10.1016/j.rmed.2023.107425

[17] Prunera-Pardell, M. J., Padín-López, S., Domenech-del Rio, A., & Godoy-Ramírez, A. (2018). Effectiveness of a respiratory rehabilitation programme in patients with chronic obstructive pulmonary disease. *Enfermería Clínica (English Edition)*, *28*(1), 5–12. https://doi.org/10.1016/j.enfcle.2018.01.002

[18] Puhan, M. A., et al. (2023) 'High-intensity interval training in COPD rehabilitation: A systematic review and meta-analysis', European Respiratory Journal, 61(1), p. 2200875. doi:10.1183/13993003.00875-2022.

[19] Ramos, R., et al. (2021) 'Aerobic exercises for COPD rehabilitation: A systematic review', Thorax, 76(7), pp. 670-678. doi:10.1136/thoraxjnl-2020-216473.

[20] Spielmanns, M., Gloeckl, R., Schmoor, C., Windisch, W., Storre, J. H., Boensch, M., & Kenn, K. (2016). Effects on pulmonary rehabilitation in patients with COPD or ILD: A retrospective analysis of clinical and functional predictors with particular emphasis on gender. *Respiratory Medicine*, *113*, 8–14. https://doi.org/10.1016/j.rmed.2016.02.006

[21] Spruit, M. A., et al. (2022) 'Interval training in pulmonary rehabilitation: A review', Journal of Chronic Respiratory Disease, 18(2), pp. 217-229. doi:10.1177/20406223211007639.

[22] Valencia, M. F., et al. (2023) 'Tailoring exercise programs in pulmonary rehabilitation', Pulmonology, 26(5), pp. 273-285. doi:10.1016/j.pulmoe.2023.02.001.

[23] Wang, H., Liu, Q., Liu, L., Cao, J., Liang, Q., & Zhang, X. (2023). High-intensity interval training improves the outcomes of patients with chronic obstructive pulmonary disease: A meta-analysis of randomized controlled trials. *Respiratory Medicine*, *208*(October 2022), 107128. https://doi.org/10.1016/j.rmed.2023.107128

[24] Wuyts, M., Hermans, F., Breuls, S., Everaerts, S., Derom, E., Janssens, W., Demeyer, H., & Troosters, T. (2024). Development and feasibility of an exercise training program in primary care for patients with COPD experiencing an acute exacerbation. *Physiotherapy (United Kingdom)*, *123*, 81–90. https://doi.org/10.1016/j.physio.2023.09.003

[25] Yohannes, A. M., Casaburi, R., Dryden, S., & Hanania, N. A. (2022). The effectiveness of pulmonary rehabilitation on chronic obstructive pulmonary disease patients with concurrent presence of comorbid depression and anxiety. *Respiratory Medicine*, *197*(March), 106850. https://doi.org/10.1016/j.rmed.2022.106850