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The Role of Pulmonary Rehabilitation and Physical Activity in the Prevention, Treatment and Management of Respiratory Diseases - A Comprehensive Review

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ABSTRACT
Introduction: Chronic respiratory diseases, including chronic obstructive pulmonary disease, asthma, obstructive sleep apnea, and other restrictive lung disorders, represent a growing global health challenge. These conditions not only affect an increasing portion of the population but also impose significant burdens on public

health systems. Lifestyle factors such as smoking, air pollution, and coexisting conditions critically influence the progression and severity of these diseases. The profound impact on mortality, quality of life, and associated complications underscores the need for interventions that extend beyond symptom control. Comprehensive patient education, psychological support, and integrated healthcare strategies are essential for effectively addressing these challenges.
Materials and Methods: A thorough review of literature was conducted using databases like PubMed, NCBI, and Google Scholar. Search terms included "pulmonary rehabilitation," "physical activity," "respiratory system diseases," and "respiratory symptoms".
State of knowledge: Pulmonary rehabilitation is a therapy designed for individuals with chronic respiratory diseases. A core component consists of supervised physical training, complemented by nutritional counseling, psychological support, and disease management education. Pulmonary rehabilitation has demonstrated effectiveness in improving lung function, exercise capacity, and alleviating dyspnea. Additionally, the integration of psychological aspects further benefits patients by reducing anxiety and enhancing symptom control. Furthermore, regular physical activity has been shown to reduce the risk of pneumonia and lung cancer. Conclusions: Pulmonary rehabilitation improves physical activity, exercise tolerance, and quality of life, while reducing symptoms. It also lowers the risk of severe lung diseases. As such, it should be a key component of both treatment and prevention, offering effective, holistic approach to patient care.

Keywords: "pulmonary rehabilitation", "physical activity", "respiratory system diseases"

INTRODUCTION

Chronic respiratory diseases, including COPD (Chronic Obstructive Pulmonary Disease), asthma, obstructive sleep apnea and other restrictive lung conditions are becoming an increasingly significant issue, not only affecting a growing segment of the population but also posing a considerable challenge to public health systems worldwide. These conditions drastically reduce the quality of life due to numerous complications and significantly shorten life expectancy. In 2017, it was estimated that over half a billion people suffered from chronic respiratory diseases, and nearly 4 million deaths were attributed to these conditions [1]. By 2019, asthma was identified as the most common chronic respiratory disease, affecting 262.4 million individuals, while the highest mortality rates were observed in patients with COPD [2]. However, it is important to highlight that many factors influence the course and severity of these diseases. Among them, lifestyle plays a critical role, identified by M. Lalonde as the most important determinant of health. Smoking, exposure to mold in homes, air pollution, and coexisting illnesses particularly mental health conditions such as depression contribute to a decline in quality of life and lead to more frequent exacerbations and hospitalizations [3,4,5].

The impact of chronic respiratory diseases on mortality, complications, and quality of life is profound. Addressing these challenges requires effective interventions that go beyond symptom management. These include comprehensive patient education, psychological support, and coordinated healthcare strategies. By empowering patients and providing holistic care, it is possible to mitigate the burden of these conditions and improve treatment outcomes.

MATERIALS AND METHODS

The study used a systematic approach to review the literature, focusing on trusted databases like PubMed, NCBI, and Google Scholar. Keywords such as “pulmonary rehabilitation”, “physical activity”, “respiratory system diseases” and “respiratory symptoms” were used to find relevant studies, ensuring a broad and thorough search. Only articles available in full-text format were included to guarantee access to complete and reliable information.The selected studies, including clinical trials and experimental research, were carefully reviewed for their methods, participant details, and reported results. Each study was also assessed for its reliability and importance to the research topic.

STATE OF KNOWLEDGE

1. Pulmonary rehabilitation

Pulmonary rehabilitation (PR) is defined as a comprehensive, multidisciplinary intervention designed for patients with chronic respiratory diseases, aiming to reduce the non-respiratory consequences of these

conditions [6]. It is delivered over several weeks, following a comprehensive patient assessment, and includes supervised exercise training as its main focus. Other key components may involve nutritional counseling, psychological support, and education on disease management. A fundamental aim of PR is to enhance physical activity (PA), exercise tolerance, and health-related quality of life, while alleviating symptoms and reducing healthcare resource utilization [7].

PR typically involves a multidisciplinary team that may include pulmonologists, physiotherapists, dietitians, psychologists, and social workers. The diversity of expertise allows the program to address a wide range of patient needs, such as skeletal muscle deconditioning, psychological distress, and nutritional deficits [7].

Exercise training, the primary component of PR, is grounded in established physiological principles such as progressive overload, specificity, and reversibility. In order to reverse skeletal muscle abnormalities, exercise training must be of high intensity to provide an anabolic stimulus, and needs to be applied 3 times per week for a minimum of 8 weeks [8].

Resistance training, a cornerstone of pulmonary rehabilitation, involves progressive overload exercises targeting major muscle with intensities ranging from 55% to 85% of heart rate reserve. This modality significantly enhances skeletal muscle strength and endurance, reduces metabolic demand during physical activity, and alleviates symptoms such as dyspnea and fatigue. Its efficacy is particularly notable in individuals with severe ventilatory limitations, where it compensates for reduced exercise tolerance from traditional aerobic training. Advanced techniques, including neuromuscular electrical stimulation and anabolic interventions such as testosterone supplementation, may further amplify its benefits [8]. Resistance training targets muscle strength, particularly the quadriceps and shoulder girdle, through functional exercises (e.g., sit-to-stand, step-ups, and wall squats) or equipment-based programs using free weights or multigyms, progressing from one set of 8–12 repetitions to three sets as tolerated [9].

Lower limb endurance training, a central component, involves ground-based walking or treadmill training at 80% of the average six-minute walk test (6MWT) speed, or cycling at >60% peak power; durations start at 15–20 minutes for deconditioned patients, progressing to at least 30 minutes using interval training if necessary to manage dyspnea [9].

Upper limb exercise training in pulmonary rehabilitation for chronic obstructive pulmonary disease (COPD) includes endurance exercises, such as arm crank training or lifting dowels, and resistance training using weights or bands. Protocols span 4–16 weeks with 2–5 sessions weekly at 60–80% one-repetition maximum or fatigue tolerance. Unsupported endurance training improves arm endurance and reduces dyspnea, though quality of life benefits are inconclusive. Combined upper and lower limb training enhances endurance but does not significantly improve dyspnea or quality of life, requiring further research to optimize regimens [10].

Another impactful exercise in pulmonary rehabilitation is yoga. Recent studies affirm yoga as a viable adjunct therapy in pulmonary rehabilitation for COPD. A meta-analysis of five randomized controlled trials (233 participants) by Liu et al. [11] revealed significant improvements in lung function and exercise capacity. Forced expiratory volume in one second (FEV1) increased by 123.57 mL (95% CI: 4.12–243, p=0.04), surpassing the minimal clinically important difference (MCID) of 100 mL. FEV1% predicted improved by 3.90% (95% CI: 2.27–5.54, p<0.00001), and the 6-minute walking distance rose by 38.84 m (95% CI: 15.52–62.16, p=0.001), exceeding the MCID of 26 m.

Crucial component of every PR are stretching exercises. Stretching exercises enhance flexibility, joint mobility, and muscle length, reducing injury risk and minimizing delayed onset muscle soreness. These exercises focus on thoracic mobility (e.g., thoracic spine rotation), accessory respiratory muscles (e.g., pectoral stretches to counteract shortening from forward-lean postures), and lower limb muscles (e.g., quadriceps and calf stretches). Stretching is typically integrated into a 5–10 minute warm-up or cool-down routine within sessions and supports, but does not replace, core endurance and strength training components. Personalized plans ensure stretching targets specific risks, improving comfort and readiness for intensive exercise [9].

Supplemental strategies like interval training, rollators, or oxygen therapy enhance exercise tolerance for severely symptomatic patients, while thorough safety protocols—including heart rate, SpO_2 monitoring, and adjustment for comorbidities—ensure patient well-being during sessions [9].

2. Asthma

Asthma is a heterogeneous, chronic respiratory disease characterized by reversible bronchial obstruction and typical symptoms such as cough, wheezing, shortness of breath, and a feeling of tightness in the chest. The symptoms vary in frequency and intensity, which is associated with varying degrees of airflow obstruction in the airways. This variability in symptoms plays a key role in the diagnosis of the disease [12].

Asthma can be classified by etiology into allergic asthma, which is typical in children, and non-allergic asthma, which occurs mostly in adults. [12].

An important aspect of asthma treatment is the consistent adherence to medical recommendations by patients, and therefore, effective patient education is a key responsibility of the attending physician. Regular use of medications, especially inhaled corticosteroids, enables effective symptom control and helps prevent disease exacerbations. It is also crucial for patients to follow the prescribed dosing schedule and proper inhalation techniques, as incorrect use of medications can significantly reduce their effectiveness [13, 14].

Physical exercise is a component of non-pharmacological treatment for asthma [15]. In a systematic review by Ma Q. et al. [15] covering 20 studies in the pediatric population, it was shown that pulmonary rehabilitation based on aerobic exercises improved Forced Vital Capacity (FVC), maximum mid-expiratory flow (FEF25-75) results, and an increase in quality of life (QoL) was observed. It was concluded that such intervention significantly improves lung function and quality of life in children with asthma.

In adults, physical activity also plays an important role in treatment. In a 12-week randomized controlled trial conducted by Valkenborghs S. R. et. al. [16], involving 46 adults, the effect of moderate-intensity aerobic training and high-intensity training on asthma symptoms was studied. Participants were divided into three groups: the first (1) performed a 45-minute moderate-intensity workout three times a week, the second (2) a 30-minute high-intensity workout three times a week, and the third (3) was a control group. It was shown that both moderate-intensity aerobic training and more intense workouts reduce asthma symptoms .

Obesity is a risk factor for asthma [17]. It can lead to reduced lung volume and compliance, as well as a decrease in the diameter of peripheral airways. Additionally, an increase in fat tissue in obese individuals leads to inflammation, elevated levels of pro-inflammatory cytokines, and adipokines in the serum, which may have a causal relationship with asthma, although research results are not conclusive. Obese asthma patients may respond poorly to inhaled corticosteroids, making symptom control more difficult [18]. Therefore, obesity prevention is an important aspect of symptom control and disease prognosis.

Pulmonary rehabilitation in asthma may also include learning controlled breathing techniques, which involve calm diaphragmatic breathing with a relaxed chest and shoulder girdle. According to a meta-analysis by
T. A. Santino [19] et al., these techniques allow the bronchi to relax after forced exhalations, reducing symptoms and improving patients' well-being . Deep diaphragmatic breathing is just one of the breathing methods, as others include the Papworth Method, the Buteyko breathing technique, and yogic breathing.

Asthma increases the risk of anxiety and depression, and it can also lead to fatigue and reduced physical activity. Therefore, individual or group psychological counseling should be considered for adults with chronic asthma. Cognitive-behavioral therapy, in particular, can have a positive

impact on quality of life, improve symptom control and reduce anxiety levels, especially when conducted over an appropriate duration, depending on the patient's initial condition [20].
Incorporating elements of pulmonary rehabilitation such as education, aerobic physical activity for both adults and children, obesity prevention, breathing techniques, and psychological support can significantly improve the health and quality of life of patients with asthma.

3. Chronic Obstructive Pulmonary Disease

COPD is a progressive and debilitating respiratory condition characterized by persistent airflow limitation and chronic inflammation of the airways and lung parenchyma [21]. The main risk factors for the development of COPD include smoking, which is the most significant etiological factor [22], prolonged exposure to air pollution [23], harmful occupational factors (dust, chemicals) [24], and genetic predispositions, including alpha-1 antitrypsin deficiency[25].
Recent interest in pulmonary rehabilitation and the role of physical activity in the management and progression of respiratory diseases, including COPD, has significantly increased. Pulmonary rehabilitation has proven to be an effective therapeutic approach for patients with stable COPD and those recovering from

exacerbations. A central component of this therapy is physical exercise, which can be adapted to accommodate the limitations of patients, enhancing movement efficiency while positively influencing both cardiovascular and muscular systems. Key training modalities include varying intensity exercises, interval training, resistance training, neuromuscular stimulation, as well as inspiratory muscle training and whole-body vibration [26]. One study evaluated the effects of chest wall vibration combined with aerobic training within a standard pulmonary rehabilitation program. In patients with COPD who participated in this training, a significant improvement in exercise capacity was observed, as measured by the 6-minute walk test. However, no significant changes were found in dyspnea, respiratory muscle function, or quality of life. These findings suggest that while chest wall vibration may enhance exercise capacity in COPD patients, its impact on other clinical parameters, such as dyspnea, remains limited [27]. Patients with symptomatic COPD, those recovering from exacerbations, and those awaiting lung transplantation are good candidates for rehabilitation [26].
Gallo et al. [28] conducted a randomized clinical trial to assess the impact of water-based interval aerobic training on heart rate (HR) variability, QoL, and functional capacity (FC) in patients with COPD. After 24 training sessions, significant improvements were observed in all evaluated parameters in the training group, while no significant changes were noted in the usual care group. Additionally, negative correlations were found between HR variability and QoL, as well as between FC and QoL, highlighting the positive effects of water-based training on the health and functional status of COPD patients.
Another study assessed the impact of walking training on quality of life and exercise capacity in individuals with COPD. After 8-10 weeks of supervised training, significant improvements were observed in quality of life among the participants in the training group, as measured by the St George's Respiratory Questionnaire (SGRQ) (mean difference -6 points; $p<0.003$) and the Chronic Respiratory Disease Questionnaire (CRDQ) (mean difference 7 points; $p<0.01$), as well as in exercise capacity in the Endurance Shuttle Walk Test (mean difference 208 seconds; $p<0.001$). These results suggest that walking training is an effective method for improving both quality of life and physical endurance in patients with COPD [29].
Cui et al. [30] conducted a study involving 366 COPD patients, demonstrating the beneficial effects of endurance training (ET) and resistance training (RT) in combination with standard treatment, as well as the long-term benefits after the completion of training. Although the differences in exercise capacity favoring ET were statistically significant, they should be

interpreted with caution. In patients with more advanced stages of COPD (GOLD C and D), the improvement in quality of life following ET or RT was significantly greater than with medical treatment alone, and RT provided a greater improvement in anxiety compared to ET. The results suggest that patients in advanced stages of COPD may gain greater benefits from both ET and RT and should be encouraged to engage in physical activity.

Pulmonary rehabilitation and physical activity play a key role in the comprehensive management of COPD. By improving physical fitness, reducing dyspnea, and providing psychological support, rehabilitation programs contribute to enhancing the quality of life for patients and reducing the burden associated with the disease.

4. Obstructive Sleep Apnea

Obstructive sleep apnea (OSA) is a common sleep disorder characterized by repeated blockages of the upper airway during sleep, resulting in intermittent airflow reduction or cessation and disrupted breathing patterns [31]. People with OSA often have comorbid conditions like hypertension, coronary artery disease, atrial fibrillation, heart failure, and stroke, underscoring its significant impact on cardiovascular health [32,33]. Cardiovascular disease remains a leading cause of global morbidity and mortality [33], and the low physical activity levels observed in OSA patients may contribute to increased obesity and cardiovascular risks. Moderate activities, such as walking, can mitigate these risks by improving respiratory function, lowering systemic inflammation, enhancing insulin sensitivity, and boosting cardiovascular health. These benefits help reduce the long-term risks associated with OSA [34]. A study of 72 patients [35] showed that combining a very low-calorie diet with active lifestyle counseling led to significant weight loss and improvements in mild OSA, which were sustained after one year. Therefore, promoting physical activity should be a priority in managing OSA [36].

Engaging in regular physical activity, including aerobic and resistance training, significantly lowers the apnea-hypopnea index (AHI), a key indicator of OSA severity. Combined exercise programs are often more effective than aerobic exercises alone [37]. Research by Peng J. et al. [37] demonstrated that exercise reduces

excessive daytime sleepiness, enhances sleep quality (as measured by the Epworth Sleepiness Scale and Pittsburgh Sleep Quality Index), and improves cardiopulmonary fitness, all of which benefit OSA patients.

Hall’s study [38] highlights physical activity as a preventive measure for OSA, finding that higher total physical activity, vigorous exercises, and walking were linked to lower OSA prevalence, independent of body mass index. Another study showed that a 12-week physical activity program for OSA patients aged over 50 improved both physical activity levels and OSA severity, even without significant weight loss. Structured exercise programs tailored to individual fitness levels have demonstrated high adherence and efficacy among middle-aged adults with OSA [39].

It’s worth mentioning that continuous positive airway pressure (CPAP) therapy effectively alleviates OSA symptoms and enhances quality of life, but it has limited influence on increasing physical activity levels. Incorporating physical activity into treatment plans can improve OSA-related signs and address cardiometabolic risks, particularly for those with poor adherence to CPAP. Therefore, it is crucial to adopt combined treatment approaches for OSA patients to effectively manage risk factors and minimize long-term morbidity and mortality [36].

Although physical activity cannot cure OSA, it plays a significant role in managing the condition and lessening its severity. While CPAP remains the gold standard treatment for moderate to severe OSA, incorporating physical activity can enhance its benefits by improving cardiovascular fitness, reducing inflammation and addressing comorbidities such as obesity and hypertension. Structured exercise programs are particularly beneficial for individuals who use them alongside CPAP therapy [36], as well as for those with low adherence to CPAP [40]. Exercise interventions, particularly aerobic and resistance training, can reduce AHI by 5–9 events per hour, even with minimal weight loss, underscoring additional benefits like improved upper airway muscle tone [37]. Specific exercises targeting throat and respiratory muscles have also shown potential to reduce AHI, decrease daytime sleepiness, stabilize the airways, and reduce snoring intensity [41].

OSA is a multifaceted condition with complex causes, requiring innovative therapeutic approaches alongside traditional treatments. For example, treatments targeting the genioglossus muscle, a primary upper airway dilator, can be effective when combined with other therapies, though their isolated use may be less impactful. Nerve electrical stimulation offers a safe alternative for moderate to severe OSA, but its invasiveness and high cost limits widespread use. Myofunctional therapy, involving exercises to strengthen airway muscles, can benefit non-obese patients with mild to moderate OSA and improve CPAP adherence, though its effectiveness depends on consistent patient participation [42].

Pulmonary rehabilitation is gaining traction as an adjunct to standard OSA treatments like CPAP. PR, which combines physical exercises, respiratory training, and lifestyle changes, improves respiratory function, reduces symptom severity, and enhances quality of life. Mendelson et al. [36] found that a 12-week PR program combining exercise and dietary adjustments significantly improved AHI, oxidative stress, and exercise tolerance in OSA patients, offering benefits beyond CPAP-only therapy . Breathing exercises and respiratory muscle training within PR strengthen the upper airways, stabilize the airways during sleep and are particularly helpful for mild-to-moderate OSA cases [40]. PR has been linked to improvements such as reduced daytime sleepiness, enhanced oxygen saturation, and decreased systemic inflammation, thus improving quality of life. Cost-effective, home-based tele-rehabilitation programs have shown similar effectiveness to in-center PR, increasing accessibility and adherence [43].

In conclusion, while PR can‘t replace CPAP, it serves as a valuable complementary strategy to enhance treatment outcomes, improve physical fitness, and manage comorbidities in OSA patients. Integrating PR into standard OSA management can significantly benefit individuals across varying levels of disease severity.

5. Interstitial Lung Diseases

Interstitial lung diseases (ILDs) are a heterogeneous group of disorders that affect the pulmonary interstitium, airways and alveoli. The most common forms include idiopathic pulmonary fibrosis (IPF), sarcoidosis, pneumoconiosis, and connective tissue disease (CTD)-associated ILD (CTD-ILD) [44]. The main pathogenic factors are fibrosis and inflammation, which occur in varying proportions and stages of progression [45]. However, the exact pathogenic processes haven't been established for all types of ILDs yet [46]. ILDs are characterised by decline in FVC, gas diffusion, exercise tolerance, quality of life and occurrence of respiratory symptoms such as dyspnoea and cough [47]. Many authors suggest that immune system impairment and

abnormal activation of inflammatory pathways play crucial role in pathogenesis of ILDs. [44, 48, 49]

IPF

In the study conducted by Li Shen et al. [50], 101 participants diagnosed with IPF were divided into two groups: a control group and an experimental group, which participated in a pulmonary rehabilitation program for 12 months. The rehabilitation consisted of performing breathing exercises from LHP’s RRPF three times a day. The changes between the groups were assessed at the 6th and 12th months. Both measurements indicated a smaller decrease in FEV1 and FVC in the exercise group compared to the control group. The 6MWD (6-minute walk distance) at the 6th month in the exercise group was close to baseline levels before the study, whereas it decreased in the control group. In the 12th month, researchers observed a decrease in 6MWD in both groups, but the decline was significantly smaller in the exercise group. Moreover, DLCO improved after 6 months in the experimental group and decreased less after 12 months compared to the control group. In both assessments (after 6 and 12 months), DLCO declined in the control group. Based on these results, the authors suggest that breathing exercises can help delay the progression of pulmonary function decline in patients with IPF

Sarcoidosis
The research by Heidrun Lingner et al. [51] aimed to assess the impact of pulmonary rehabilitation on patients with sarcoidosis. The study included 296 individuals who underwent 3 weeks of PR. The mandatory activities included:

- Endurance walking (e.g., Nordic walking) 3–5 times per week
- Strength training 3 times per week
- Respiratory physiotherapy 3 group sessions and 2 individual sessions, totaling 5 sessions
- Educational modules
- Diagnosis confirmation by a lung specialist

The study lasted for 3 weeks. The results showed an increase of 39.8 meters in 6MWD (mean 6MWD before rehabilitation: 505.2 meters). Improvements were also seen in the SGRQ scale, with a 8.3-point improvement in "symptoms" and a 7.8-point improvement in "activity". The Fatigue Assessment Scale (FAS) showed an improvement of 4.09 points, and the HADS anxiety scale improved by 1.6 points. Notably, PR also reduced symptoms in the examined patients. Before the study, more than 92% of patients reported exercise intolerance, while after rehabilitation, only 78%. Other symptoms, such as dyspnoea, joint pain, cough, and fatigue, also decreased. The researchers emphasize that PR can play an important role as a complementary therapy."

Pneumoconiosis
Eric W. Tsang et al. [52] examined the impact of community-based pulmonary rehabilitation (CBPR) and home-based pulmonary rehabilitation (HBPR), delivered by healthcare professionals, on patients diagnosed with pneumoconiosis. Symptom changes were assessed using the CRQ (Chronic Respiratory Disease Questionnaire) to measure health-related quality of life (HRQL). CBPR led to improvements in CRQ scores for dyspnoea, fatigue, emotion, mastery, and knowledge. The mean improvement in exercise capacity, as measured by the 6MWT, was 59.5 meters for CBPR and 47.6 meters for HBPR. However, HBPR did not improve HRQL or psychological symptoms among patients. Both interventions led to a significant decrease in the HADS (Hospital Anxiety and Depression Scale) anxiety scores.

Connective tissue diseases (CTD)-associated ILD
The study by Leona M. Dowman et al. [53] included 142 patients with ILDs, of whom 23 had CTD-ILD. The research assessed the impact of pulmonary rehabilitation on various parameters,

such as 6MWD, SGRQ-I (the IPF-specific version of the St. George's Respiratory Questionnaire), and CRDQ. The experimental group participated in different exercises twice a week for 8 weeks. The training program included 30 minutes of aerobic exercise, cycling, walking, and resistance training. Measurements were taken after 6 months. The results showed that patients with CTD-ILD experienced improvements in the SGRQ-I and CRDQ dyspnoea scales. Additionally, the study revealed a modest increase in 6MWD. The authors suggest that patients with CTD-ILD

can also benefit from PR.

As evidenced by the studies referenced, pulmonary rehabilitation and physical activity can play a crucial role in the management of interstitial lung diseases by alleviating symptoms, improving exercise tolerance and life quality. In the light of benefits that can be achieved, pulmonary rehabilitation should be considered as a valuable tool in everyday medical practice and recommended to patients with interstitial lung diseases.

6. Respiratory Tract Infections

Respiratory tract infections (RTIs) remain a significant global health concern, encompassing various conditions from upper respiratory tract infections to severe pneumonia and COVID-19. Recent studies have demonstrated the crucial role of physical activity in both prevention and management of these conditions.

In type 2 diabetic patients with COVID-19, physical activity has shown particular importance in disease management. Exercise interventions must be carefully tailored, with low-intensity exercises being most beneficial for elderly diabetic patients with COVID-19 [54]. The implementation of tailored physical activity programs has shown significant benefits in enhancing overall immune response and managing inflammatory markers, including reduced levels of pro-inflammatory cytokines such as IL-6 and TNF-α [54]. These exercise interventions must be carefully monitored and individualized based on patient condition, focusing on maintaining physical function without overexertion. Regular aerobic exercise programs have shown remarkable effectiveness in improving both physical and mental health outcomes in COVID-19 patients. Specifically, cycling or walking at 60-80% of HR max for 20-60 minutes, 2-3 times weekly, has demonstrated improvements in immune function by increasing immunological markers, including lymphocytes, leukocytes, neutrophils, monocytes, and interleukin-6, while simultaneously reducing low-grade inflammation [55].

In the context of COVID-19, physical activity has shown remarkable benefits in both prevention and treatment phases of the disease. Studies indicate that structured physical activity contributes significantly to promoting recovery of physical function and alleviating post-acute COVID-19 syndrome symptoms [56]. A systematic review of 35 studies demonstrated that 97% of studies showed significant increases in functional capacity parameters, while 96% reported improvements in quality of life, mental health, and general state. Even minimal physical activity interventions, such as postural changes and short walking sessions twice daily for severe cases, or low exercise volumes of 120 minutes per week for mild-to-moderate cases, showed positive outcomes [57]. An 8-week rehabilitation program incorporating exercise, education, dietary, and psychological support demonstrated significant improvements in respiratory symptoms and fatigue levels among post-COVID-19 patients. The rehabilitation group showed markedly better outcomes in the COPD Assessment Test and various fatigue assessment metrics compared to the usual care group [58].

Pulmonary rehabilitation offers significant benefits for tuberculosis patients, demonstrating improvements across multiple health domains. Studies have shown that PR programs effectively enhance pulmonary function parameters, including FEV1 and FVC [59]. A

comprehensive four-week pulmonary rehabilitation program has demonstrated notable improvements in exercise endurance, as measured by 6MWT, and quality of life metrics using the SGRQ [59]. Post-tuberculosis patients often face persistent functional challenges even after completing pharmacological treatment. Structured rehabilitation interventions have proven effective in addressing these residual issues, improving functional capacity, and enhancing overall quality of life [60]. The rehabilitation process is particularly crucial for patients with post-TB bronchiectasis, who show significant improvements in both physical function and respiratory parameters following structured PR programs [59,61].
Physical activity demonstrates significant effects on both the course and prevention of community-acquired pneumonia (CAP). A systematic review and meta-analysis encompassing 10 prospective studies with over a million participants has shown that regular physical activity substantially reduces the risk of developing pneumonia. The pooled analysis revealed that individuals who were most physically active had a 31% lower risk of pneumonia compared to those who were least active (RR 0.69, 95% CI 0.64-0.74). This protective effect was particularly strong for pneumonia-related mortality (RR 0.64, 95% CI 0.59-0.70) compared to incident pneumonia (RR 0.82, 95% CI 0.72-0.93). These results demonstrate that regular physical activity serves as a significant protective factor against both the development of pneumonia and pneumonia-related mortality, highlighting its importance in preventive healthcare strategies [62].

Hospital-based physiotherapy in elderly patients with CAP yields measurable benefits. Patients receiving physical therapy (minimum 0.5 hours daily) show significantly lower 30-day hospital readmission rates, with a 35% reduction compared to the control group. This early intervention strategy proves particularly effective in preventing complications and supporting faster recovery [63]. Physical rehabilitation programs are especially crucial for patients with reduced physical function. While the immediate impact on Activities of Daily Living (ADL) during hospitalization might not be immediately apparent, the long-term effects of rehabilitation are significant for the recovery process. Early implementation of physical activity, even at minimal levels, can contribute to faster recovery and prevention of complications [63].

7. Lung Cancer

Lung cancer (LC) is a complex neoplasm that mainly includes two histological subtypes: non-small cell lung cancer (NSCLC) and small cell lung cancer (SCLC) [64]. LC is characterized by molecular and histological diversity, which affects its pathophysiology and clinical course [64]. Symptoms may include cough, shortness of breath, and chest pain, as well as general symptoms such as weight loss and fatigue. In the treatment of NSCLC, significant progress has been made through targeted therapies and immunotherapies, which have significantly improved treatment outcomes. However, in the case of SCLC, progress in treatment is limited, resulting in no significant improvement in survival for patients with this subtype of LC [64].
Physical activity plays a crucial role in reducing the risk of LC. The meta-analysis by R. Qie et al. [65] demonstrated that total physical activity (TPA) is inversely correlated with the risk of LC, with the highest level of TPA associated with a 22% reduction in risk (RR: 0.78; 95% CI: 0.70-0.86). Similarly, leisure-time physical activity (LTPA) also shows a significant association with reduced LC risk, with a 12% risk reduction for the highest level of LTPA (RR: 0.88; 95% CI: 0.83-0.93) [65]. Dose-response analysis revealed a nonlinear relationship between LTPA and LC risk, with the lowest risk observed at an activity level of 15 metabolic equivalent of task (MET) hours per week [65]. In contrast, studies by X. Diao et al. [66] found that increasing PA levels to 13,200 MET-minutes per week was associated with a 14.7% reduction in LC risk (RR:

0.853; uncertainty interval: 0.798-0.912), highlighting the importance of PA as a preventive measure.
Pulmonary rehabilitation and physical activity play a crucial role in the treatment of LC patients, particularly those undergoing surgical procedures. Studies indicate that PA before a LC diagnosis can significantly improve patient survival. C.M. Friedenreich et al. [67] analyzed 11 cohort studies and found that individuals engaging in recreational PA with an intensity of at least 8.3 MET-hours/week had a 7% lower risk of all-cause mortality compared to inactive individuals, and patients with localized cancer experienced a 20% reduction in lung cancer-specific mortality. Additionally, their systematic review and meta-analysis showed that PA before diagnosis reduces the risk of lung cancer-specific mortality by 19% (HR = 0.81, 95% CI = 0.75 to 0.87), while PA after diagnosis reduces the risk by 27% (HR = 0.73, 95% CI = 0.60 to 0.94).
However, the level of PA among LC patients is often low. W. Zhou et al. [68], in their systematic review, indicate that only 23-28% of patients meet the PA recommendations (150 minutes/week of moderate to vigorous physical activity) within 6 months to 6 years post-surgery. Before surgery, patients averaged between 3,822 and 10,603 steps per day, and from 1 to 3 months post-surgery, they averaged between 3,934 and 8,863 steps.
Pulmonary rehabilitation programs are designed to improve patients' physical and mental functions, as well as promote long-term health behaviors. X. Mao et al. [69] recommends a comprehensive approach to PR including endurance training, resistance exercises, and inspiratory muscle training. Preoperative rehabilitation lasting about two weeks (5 days a week) can prepare patients for surgery by improving cardiopulmonary function and reducing the risk of surgical complications. On the other hand, postoperative rehabilitation lasting from 1 to 2 months helps in reducing dyspnea, exercise intolerance, and pain associated with the surgical wound, as well as improves patients' mental state.
A study by A. Imperatori et al. [70] demonstrated that kinesiotaping (KT) can be an effective and safe adjunctive method for pain control after lung lobectomy for cancer. Patients in the KT group generally reported less chest pain than the control group. The difference was statistically significant on day 5 after surgery (median VAS 2 vs 3, $P < 0.01$) and day 8 (median VAS 1 vs 2, $P < 0.05$). At 30 days post-surgery, persistent chest pain (VAS $\geq$3) was less frequently reported in the KT group compared to the control group (7% vs 24%, $P = 0.03$).

No adverse events related to KT application were observed. Both groups had similar outcomes in terms of additional analgesia, complications, chest tube duration, and length of hospital stay.

8. Cystic fibrosis

Cystic fibrosis (CF) is an autosomal genetic disorder resulting from mutations in the CFTR (Cystic Fibrosis Transmembrane Conductance Regulator) gene, leading to impaired chloride conductance through epithelial cells. These mutations cause various clinical phenotypes, such as airway obstruction, pancreatic insufficiency, meconium ileus, and infertility in men due to congenital bilateral absence of the vas deferens [71]. Many studies emphasize the role of physical activity in the management and rehabilitation of patients suffering from CF [72,73]. Selvadurai et al. conducted a randomized controlled trial comparing the effects of aerobic and strength training in children with CF aged 8-16 years hospitalized due to disease exacerbation. They demonstrated that patients undergoing aerobic training achieved significantly better results in terms of peak aerobic capacity, activity level, and quality of life compared to the strength training group. The strength training group achieved better results in terms of weight gain, lung function, and leg muscle strength. This study suggests that a combination of aerobic and strength training may be the optimal approach in the rehabilitation of CF patients [73,74].

On the other hand, Klijn et al. [75] investigated the impact of a 12-week anaerobic training program in children with CF. They observed significant improvements in anaerobic and aerobic performance among program participants and a significant improvement in quality of life measured using a CF-specific questionnaire [76].

Selvadurai et al. [77] analyzed the relationship between PA levels and functioning and quality of life in patients with CF. They demonstrated significant correlations between activity levels and aerobic capacity ($r = 0.55$; $p < 0.01$), anaerobic power ($r = 0.63$; $p < 0.01$), and quality of life ($r = 0.61$; $p < 0.01$). This study emphasizes the importance of maintaining PA, especially after puberty, when CF patients tend to decrease their activity levels.

Another significant study is the randomized controlled trial conducted by Hebestreit and colleagues [78], which evaluated the long-term effects of a 6-month, partially supervised conditioning program in patients with CF. The clinical trial involved 38 patients aged 12-40 years, who were assigned to either an intervention group (n=23) or a control group (n=15). The intervention group followed an individual exercise program for at least 3 hours per week for 6 months. The primary endpoint was peak oxygen uptake (VO2peak). After 18-24 months of follow-up, statistically significant differences were found between the groups in favor of the intervention group regarding VO2peak: $+3.73 \pm 1.23$ mL·min^-1·kg^-1 (p=0.002), maximal workload: $+0.37 \pm 0.11$ W·kg^-1 (p=0.001), vigorous physical activity: $+1.63 \pm 0.82$ hours/week (p=0.047), forced vital capacity: $+6.06 \pm 2.87\%$ of predicted value (p=0.035), and subjective health assessment: $+9.89 \pm 4.72$ points (p=0.036). The results indicate that a 6-month home-based exercise program leads to long-term improvements in physical fitness, activity, and lung function in patients with CF, persisting for over a year after the intervention ended [78,79].

Physical exercises, including breathing techniques, contribute to improved lung function. In the study by Schneiderman-Walker et al., the intervention group, which participated in a three-year home exercise program, showed a smaller annual decline in the percentage of predicted FVC and FEV1 compared to the control group [79,80].

Respiratory rehabilitation, with a particular focus on kinesitherapy, plays a crucial role in the treatment of CF. Kinesitherapy, including physical exercises and airway clearance techniques (ACT), has a significant impact on the course of the disease and the quality of life of patients. Regular physical activity in people with CF is associated with a slower decline in FEV1, as demonstrated in a 9-year study involving over 200 patients. A meta-analysis of three studies showed that adding exercises to ACT significantly increases FEV1 compared to ACT alone. Moreover, exercise programs improve physical capacity, chest mobility, and maintain bone mineral density, which translates into a better quality of life for CF patients [81].

CONCLUSIONS

The described methods of treatment, in the form of broadly defined pulmonary rehabilitation, aim to enhance physical activity, improve exercise tolerance, and increase overall quality of life, while also reducing symptoms and minimizing the need for healthcare services. Additionally, it has been shown to reduce the risk of developing certain severe lung diseases.

Therefore, these interventions should be considered as one of the key components in the treatment and prevention of respiratory diseases. By providing a holistic approach to care, we can more effectively improve patient outcomes.

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- Conceptualization: K.K
- Data Curation: K.K., T.M., P.M., J.S., B.Z., J.D., Ł.S.P., P.H., A.S., M.Ł.
- Formal Analysis: K.K., T.M., P.M., J.S., B.Z., J.D., Ł.S.P., P.H., A.S., M.Ł.
- Investigation: K.K., T.M., P.M., J.S., B.Z., J.D., Ł.S.P., P.H., A.S., M.Ł.
- Methodology: K.K., T.M., P.M., J.S., B.Z., J.D., Ł.S.P., P.H., A.S., M.Ł.
- Project Administration: K.K., T.M., J.D.
- Resources: K.K., T.M., P.M., J.S., B.Z., J.D., Ł.S.P., P.H., A.S., M.Ł.
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