The Egyptian Journal of Hospital Medicine (July 2025) Vol. 100, Page 4357-4362

# The Impact of Pulmonary Rehabilitation on Quality of Life in Lung Transplant Candidates: A Systematic Review

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## ABSTRACT

**Background:** Patients awaiting or who have undergone lung transplantation often suffer from reduced quality of life (QoL) and limited exercise capacity. Pulmonary rehabilitation (PR) is a key intervention to address these issues, but a comprehensive synthesis of its specific effects on this population is lacking. **Objective:** This study aimed to evaluate the efficacy of PR on QoL and exercise capacity in lung transplant candidates and recipients. **Methods:** This systematic review that was conducted in accordance with PRISMA guidelines. A comprehensive search used ScienceDirect, PubMed, Scopus, and Google Scholar for Pulmonary Rehabilitation, Lung Transplantation, Quality of Life and COPD through studies published from 2014 to 2024. Data were extracted using a TIDieR-based form, and risk of bias was assessed using the CASP and JBI tools. Six studies (four randomized controlled trials and two quasi-experimental) with a total of 315 patients were included. **Conclusion:** The included studies consistently demonstrated that PR significantly improved physical health-related QoL and exercise capacity. Improvements were most notable in physical functioning, vitality, and general health domains. However, the impact on mental health was more variable. Longer program durations appeared to be associated with greater QoL improvements. Pulmonary rehabilitation is an effective intervention for enhancing the physical health and exercise capacity of lung transplant patients. Our findings emphasized the need for standardized, long-term programs to maximize these benefits. Future research should focus on optimizing PR protocols and determining the ideal duration to achieve more consistent improvements in mental health.

**Keywords:** Pulmonary rehabilitation, Lung transplantation, Quality of life, COPD.

## INTRODUCTION

Patients with advanced lung diseases like chronic obstructive pulmonary disease (COPD), cystic fibrosis, and idiopathic pulmonary fibrosis often experience a severe decline in their quality of life (QoL) and exercise capacity [1, 2]. This decline is characterized by heightened ventilatory limitation, muscle weakness, and exercise limitations, which negatively impact their overall health and well-being and are often exacerbated by comorbidities [3, 4]. As a result, these patients face a significant burden during the waiting period for a lung transplant, despite receiving optimal medical treatment.

Pulmonary rehabilitation (PR) has emerged as a crucial, evidence-based intervention to manage these deficits. PR programs, which are multidisciplinary and comprehensive, typically include exercise training, education, and psychosocial support [5]. These programs are designed to address the physical and psychological burdens of advanced lung disease, improve functional status, and prepare patients for transplantation [6].While numerous studies have shown that PR can significantly improve QoL and exercise capacity in these patients, a comprehensive and transparent evaluation of the current evidence is needed. The current evidence suggests that PR may have a positive effect; however, more research is needed to better understand the extent and mechanisms of these benefits [7, 8]. Therefore, a systematic review is crucial to synthesize the available data, minimize biases, and provide a clear understanding of the potential benefits of PR in this population.

The primary objective of this systematic review was to meticulously evaluate and synthesize existing research concerning the efficacy of pulmonary rehabilitation programs on enhancing health-related quality of life and exercise capacity in individuals awaiting or who have undergone lung transplantation.

## SUBJECTS AND METHODS

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The study protocol was officially registered on PROSPERO, the International prospective register of systematic reviews, under the registration number CRD42024537535.

### Search strategy and eligibility criteria

A comprehensive and transparent search of the literature was performed to identify all relevant studies. The Population, Intervention, Comparator, and Outcome (PICO) framework was applied to formulate the search strategy, as detailed in table (1). The search was limited to studies published between 2014 and 2024.



Received: 30/04/2025
Accepted: 29/06/2025

**Inclusion and exclusion criteria**

The following criteria were used to determine whether a study was included in the review:

- **Types of studies**: included randomized controlled trials (RCTs) and non-equivalent control group quasi-experimental studies. Only included studies with available full text and data sets, published in English.
- **Types of participants**: We included adult patients (over 18 years) who were either awaiting or had undergone unilateral or bilateral lung transplantation, regardless of their underlying pulmonary disease (e.g., COPD & interstitial lung disease). Studies in which most participants underwent another surgical procedure in addition to lung transplantation (e.g., heart-lung transplantation) or studies that did not include a control or comparison group were excluded.
- **Types of interventions**: We included studies assessing pulmonary rehabilitation programs, as defined by the American Thoracic Society and the European Respiratory Society. This encompassed various modalities, including aerobic, resistance, and multimodal training, as well as educational and psychosocial interventions. All programs were eligible regardless of frequency, intensity, session length, or delivery setting (e.g., gym & home).
- **Types of Outcome Measures:** The primary outcome of interest was health-related quality of life (HRQoL), as measured by validated questionnaires (e.g., SF-36, SGRQ).

**Search Methods and study selection**

We searched four electronic databases: ScienceDirect, PubMed, Scopus, and Google Scholar. We also manually searched the reference lists of relevant review articles, studies, and clinical practice guidelines. All search results were exported to Zotero reference manager to identify and remove duplicates. The study selection process followed a systematic approach:

- **Initial screening**: Titles and abstracts were independently screened by two authors. Disagreements were resolved by consensus or by a third reviewer.
- **Full-text review**: The full texts of potentially relevant studies were then assessed against the eligibility criteria in a blinded process, with conflicts resolved in the same manner. The identification, screening, and inclusion of studies are detailed in the PRISMA flow diagram.

**Data extraction and management**

Two authors independently extracted data from the included studies using a pretested and refined standardized form. This form was developed based on the TIDieR (Template for Intervention Description and Replication) checklist to ensure a comprehensive and detailed description of each intervention. Discrepancies between the reviewers were resolved through discussion, or by a third reviewer. Information extracted included study and participant characteristics, detailed intervention descriptions and outcome data. Where data was missing or unclear, authors were contacted for clarification. Attrition rates and missing data issues were critically appraised.

**Assessment of risk of bias in included studies**

The risk of bias of the eligible studies was independently assessed by two review authors. Disagreements were resolved by consensus or a third author. The Critical Appraisal Skills Programme (CASP) checklist for randomized controlled trials and the Joanna Briggs Institute (JBI) tool for quasi-experimental studies were used. A study was considered to have a low risk of bias if all assessed domains exhibited low risk. If at least one domain had an unclear or high risk of bias, the entire study was classified accordingly.

**Assessment of heterogeneity**

Heterogeneity was planned to be evaluated through both qualitative and quantitative methods. Statistical tests, including Cochran's Q statistic and the I-squared statistic were specified to quantify variance in effect sizes. However, due to the substantial heterogeneity in study designs and outcome measures, a quantitative meta-analysis was not feasible. Therefore, a narrative synthesis of the findings was conducted.

## RESULTS

**Study identification and selection:** A total of 37,660 records were identified through the database search, with 30 full-text articles assessed for eligibility after removing duplicates. Following full-text review, 6 randomized controlled trials (RCTs) met the inclusion criteria. The PRISMA flow diagram detailing the study selection process is shown in figure (1).

**Risk of bias assessment:**

This assessment was performed individually for each study, with the **Critical Appraisal Skills Program (CASP)** checklist used for the randomized controlled trials (RCTs) and the **Joanna Briggs Institute (JBI)** tool used for the quasi-experimental studies. Among the quasi-experimental studies, **Jie *et al.*** [9] and **Miozzo *et al.*** [10] were at a higher risk of bias due to their non-randomized designs. Specifically, **Jie *et al.*** [9], where use of a non-synchronous design comparing patients from different years introduced potential confounding, while **Miozzo *et al.*** [10] retrospective design showed significant baseline differences in lung function between groups. For the RCTs, the risk of bias was generally well-managed in certain domains but less so in others: **Selection Bias: Gloeckl *et al.*** [11], **Langer *et al.*** [12] and **Fuller *et al.*** [13] effectively managed selection bias through appropriate randomization and allocation concealment. **Ulvestad *et al.*** [14] also used block randomization to ensure random assignment.

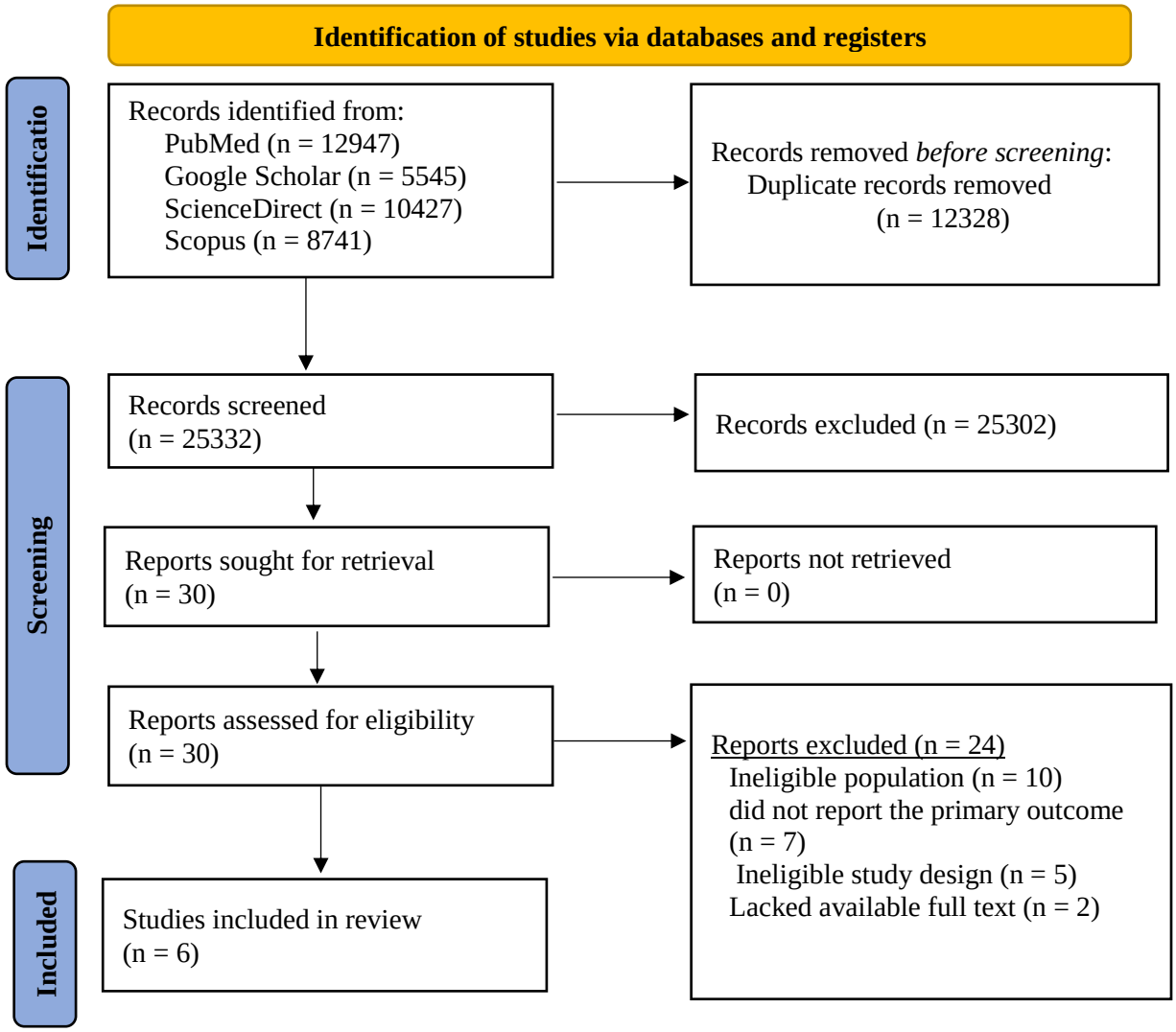


**Figure (1):** PRISMA flow diagram of studies that were assessed and included.

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**Blinding (Performance and bias detection):** Blinding was a significant source of bias. **Gloeckl *et al.*** [11] did not blind participants, and only some assessors were blinded. Similarly, **Ulvestad *et al.*** [14] acknowledged a lack of blinding as a limitation. In contrast, **Langer *et al.*** [12] used a single-blind design, which helped reduce detection bias. **Fuller *et al.*** [13] did not clearly report on blinding, leaving the risk of bias in this domain uncertain.

**Participant accounting and follow-up (Attrition bias):** Attrition bias was generally low across the studies. **Gloeckl *et al.*** [11], **Langer *et al.*** [12] and **Fuller *et al.*** [13] all used intention-to-treat (ITT) analysis or accounted for dropouts, effectively managing this type of bias. **Ulvestad *et al.*** [14] also conducted both ITT and per-protocol analyses.

**Baseline similarity and confounding factors:** While the RCTs by **Gloeckl *et al.*** [11] and **Langer *et al.*** [12] showed good baseline comparability, the non-randomized studies had significant differences that introduced confounding. For example, **Miozzo *et al.*** [10] had significant baseline differences in lung function, and **Jie *et al.*** [9] did not control for other medical factors.

**Outcome measurement and reporting:** Most studies followed guideline-based outcome measurements, with clear definitions and reported statistical data (e.g., confidence intervals and p-values). However, the small sample sizes in some studies, such as those by **Jie *et al.*** [9] and **Miozzo *et al.*** [10] limited the reliability of their findings and introduced a potential for bias.

**External Validity:** The generalizability of the findings varied. Studies with strict inclusion criteria, such as **Langer *et al.*** [12] and **Jie *et al.*** [9] are more difficult to generalize to broader patient populations. In contrast, **Ulvestad *et al.*** [14] included a more diverse patient

population, which enhanced the external validity of their findings.

Overall, the risk of bias in the included studies was a notable limitation, particularly due to the presence of quasi-experimental designs, a lack of consistent blinding, and small sample sizes.

**Characteristics of included studies**

The six studies included in this systematic review were conducted across six different countries China, Brazil, Norway, Australia, Belgium, and Germany between 2012 and 2024. Four of the studies were randomized controlled trials (RCTs), while two employed quasi-experimental designs. Four studies targeted post-lung transplant recipients [9, 12-14], whereas two focused on pre-transplant candidates [10, 11].

A total of 315 participants were included in the review, with 170 patients in the intervention groups and 145 in the control groups. The average age was similar between groups, at 54.7 ± 10.83 years for the intervention groups and 53.63 ± 10.34 years for the control groups. Consistent with the wider literature on lung transplant demographics, the majority of patients across all studies were males. Health-related quality of life (QoL) was the primary outcome in all included studies. Five of the six studies utilized the Medical Outcomes Study Short Form-36 (SF-36) questionnaire, while one study used the St. George's Respiratory Questionnaire (SGRQ). Chronic obstructive pulmonary disease (COPD) was the most common underlying lung disease among the participants, especially in the post-transplant populations.

All rehabilitation interventions were supervised by physiotherapists and delivered face-to-face. Most programs were conducted in hospital-based rehabilitation centers [9-12], while two studies [13, 14] used outpatient or hybrid settings, such as physiotherapy gyms and local fitness centers.

A uniform core component of all interventions was both aerobic and resistance exercise training. Treadmills and cycle ergometers were frequently used for aerobic activities, while leg presses and various upper limb exercises were included for resistance training. Beyond these foundational modalities, some programs integrated additional crucial elements. For instance, **Jie *et al.*** [9] specifically included breathing exercises and airway clearance, and both **Jie *et al.*** [9] and **Miozzo *et al.*** [10] provided nutritional support. Multidisciplinary education sessions were a feature of the programs by **Fuller *et al.*** [13] and **Gloeckl *et al.*** [11]. The Borg scale was consistently used for intensity monitoring in the interventions by **Miozzo *et al.*** [10], **Fuller *et al.*** [13], and **Gloeckl *et al.*** [11].

The duration of the rehabilitation programs varied considerably among the studies, ranging from brief to longer engagements. **Gloeckl *et al.*** [11] implemented a three-week program, while **Jie *et al.*** [9] intervention spanned approximately three months. Moderate-term programs of around 12 weeks were conducted by **Miozzo *et al.*** [10] and **Langer *et al.*** [12]. Longer-term rehabilitation was observed in the 20-week study by **Ulvestad *et al.*** [14] and the 14-week program with an additional six-month follow-up by **Fuller *et al.*** [13]. Despite these variations in overall length, most studies commonly scheduled three sessions per week, with individual session durations typically ranging from 30 to 90 minutes.

**Impact on health-related quality of life**

The included studies consistently demonstrate that pulmonary rehabilitation (PR) is a beneficial intervention for enhancing the quality of life (QoL) in lung transplant candidates and recipients, with improvements frequently reported in both physical and mental health domains. These outcomes were primarily measured using validated questionnaires such as the Medical Outcomes Study Short Form-36 (SF-36) and the St. George's Respiratory Questionnaire (SGRQ).

In post-transplant patients, studies showed significant QoL gains. For example, **Jie *et al.*** [9] observed a notable improvement in physical health scores on the SGRQ, with the intervention group's scores decreasing from 49.65 to 38.75 (where lower scores indicate better health), a more substantial change than in the control group. Similarly, **Fuller *et al.*** [13] found significant gains, with SF-36 physical health scores increasing from 33.1 to 71.6 and mental health scores from 48.3 to 76.2. **Langer *et al.*** [12] also corroborated these findings, reporting improvements across multiple SF-36 domains, including physical functioning, social functioning and vitality.

For pre-transplant patients, the impact of PR on QoL also showed positive results, though the extent of improvement was influenced by program duration and baseline health. **Miozzo *et al.*** [10] demonstrated significant QoL improvements in this cohort, particularly in physical functioning, social functioning and emotional roles. In contrast, the brief, three-week inpatient program by **Gloeckl *et al.*** [11] yielded only modest QoL improvements, with SF-36 physical scores remaining stable and mental scores showing a slight decrease. **Ulvestad *et al.*** [14] also noted only minor SF-36 improvements in both physical and mental health in their post-transplant cohort, suggesting that the degree of QoL enhancement can vary.

While the majority of studies demonstrated meaningful QoL improvements, the effect on mental health was more variable. **Fuller *et al.*** [13] reported substantial mental health gains, but other studies showed less pronounced effects. **Ulvestad *et al.*** [14] observed only marginal mental health improvements, and **Gloeckl *et al.*** [11] in short program showed that mental health scores remained stable. This suggests that while PR generally benefits both physical and mental QoL, its impact on

mental health may be less consistent, potentially requiring more targeted interventions or longer durations to manifest significantly. Overall, a recurring and robust finding was the significant improvement in physical health domains across five of the six studies, affirming the positive role of PR in enhancing the physical QoL of this patient population.

## DISCUSSION

This systematic review aimed to evaluate the effect of pulmonary rehabilitation (PR) on the quality of life (QoL) in lung transplant candidates and recipients. The review of six studies, which included 315 participants, consistently demonstrated that PR leads to clinically meaningful improvements in QoL, particularly within physical health domains such as physical functioning, vitality, and general health. While improvements were consistently observed in physical QoL, the gains in mental health were more variable and modest. This suggests that while PR is a reliable intervention for enhancing physical well-being, achieving significant mental health benefits may require longer program durations or more targeted psychological support.

The consistent improvement in physical QoL can be attributed to the structured exercise components—specifically aerobic and resistance training—that were a core part of all included programs. This progressive physical conditioning leads to physiological gains in exercise capacity and muscle strength, which directly translate into a greater ability to perform daily activities. In contrast, the more variable improvements in mental health may be linked to several factors, including the shorter duration of some programs and the limited psychological support provided. For example, shorter interventions, such as the three-week program by **Gloeckl *et al.*** [11] produced only modest benefits, reinforcing the idea that a longer, more sustained approach is necessary to achieve lasting QoL improvements. Additionally, differences were observed between pre- and post-transplant groups, with post-transplant patients showing more consistent QoL improvements, likely due to greater baseline impairments and a higher potential for recovery.

The findings of this review align with the broader body of evidence on PR's impact on QoL. The consistent improvements in physical health domains observed in studies like **Fuller *et al.*** [13] and **Langer *et al.*** [12] directly support the conclusions of other systematic reviews by **Hoffman *et al.*** [15] and **Abidi *et al.*** [16], which also found that PR significantly enhances QoL and exercise capacity in patients with advanced chronic lung disease. The use of validated QoL measurement tools, such as the SF-36 and SGRQ, further strengthens the credibility of these findings. However, the variability in mental health improvements noted in this review is also a known issue in the literature. Both **Abidi *et al.*** [16] and **Hume *et al.*** [17] have highlighted that while physical function consistently improves, mental health components can remain unchanged, suggesting that a more specific focus on psychological support or certain exercise modalities, like high-intensity interval training (HIIT), might be needed.

**LIMITATIONS:** This review was subjected to several limitations, most notably the significant heterogeneity across the included studies. This variability in study designs (RCTs vs. quasi-experimental), patient populations (pre- vs. post-transplant) and intervention durations precluded the possibility of conducting a quantitative meta-analysis. Consequently, it was not possible to pool data to provide a single, aggregated numerical estimate of the effect of PR on QoL. The inclusion of quasi-experimental studies also introduced a higher risk of bias due to potential confounding factors and a lack of randomization. Additionally, the small sample sizes in some studies limited their statistical power. Despite these limitations, the systematic and rigorous approach of this review ensured a high quality of evidence synthesis, and its findings provided valuable insights into the impact of PR on this specific patient population.

## CONCLUSION

This systematic review provided strong evidence that pulmonary rehabilitation significantly and clinically improved the quality of life for lung transplant candidates and recipients. While the most consistent and substantial gains are observed in physical health domains, the intervention also contributed to mental well-being, though with more variable effects. The evidence from the analyzed studies underscored the importance of a comprehensive approach, prioritizing supervised, individualized exercise regimens complemented by multidisciplinary care. These findings hold significant implications for both clinical practice and future research. For clinicians, the review advocates for making PR a standard component of care, to be initiated as early as medically feasible and delivered through adaptable, hybrid models that extend benefits beyond the clinic. For researchers, the review highlights the need for future studies to determine the optimal program duration and intensity, as well as to investigate targeted strategies and the use of technology to ensure more consistent and long-lasting improvements in both physical and mental QoL.

## ACKNOWLEDGEMENT

I would like to express my deepest gratitude to Dr. Eman Sobh Mohammad Sobh and Dr. Saif El-Deen Ahmed Ragab for their continuous guidance, patience,

and unwavering support throughout the course of this work.

**Funding:** There was no funding or financial support for this study.

**Competing interests:** The authors declare that they have no competing interest.

## REFERENCES

1. **Taylor L, Smith J, Babyak A *et al.* (2008):** Coping and quality of life in patients awaiting lung transplantation. Journal of Psychosomatic Research, 65 (1): 71–79. https://doi.org/10.1016/j.jpsychores.2008.04.009
2. **Gasperino J, Christenson A, Ismaila S (2019):** Management of advanced lung disease: A Canadian Thoracic Society clinical practice guideline update. Canadian Respiratory Journal, 2738760. https://doi.org/10.1155/2019/2738760
3. **Carpenter D, Nelson E, Johnson E (2017):** Lung transplantation in patients with comorbidities. Respiratory medicine, 123: 102-109.
4. **Dowman L, Hill C, Holland E *et al.* (2018):** The impact of pulmonary rehabilitation on exercise capacity and quality of life in lung transplant candidates. Journal of cardiopulmonary rehabilitation and prevention, 38 (2): 122-127.
5. **Jastrzebski D, Marcinowska-Suchowierska E, Wronski S (2018):** Pulmonary rehabilitation in lung transplant candidates. Journal of thoracic disease, 10 (12): S1426.
6. **Picard C, Boisseau M, De Miranda S *et al.* (2015):** Préparation des insuffisants respiratoires à la transplantation. Un état des lieux. Revue Des Maladies Respiratoires, 32 (1): 1–7. https://doi.org/10.1016/j.rmr.2014.02.007
7. **Gao W, Chen L, Liang Z *et al.* (2018):** Effectiveness of pulmonary rehabilitation in lung transplant candidates: A systematic review and meta-analysis. Clinics, 73: e152. https://doi.org/10.6061/clinics/2018/e152
8. **Chang C, Huang C, Chung P *et al.* (2020):** The effect of pulmonary rehabilitation in lung transplant candidates: A systematic review and meta-analysis. Respiratory Care, 65 (9): 1299–1310. https://doi.org/10.4187/respcare.07617
9. **Mei J, Hu J, Krause E *et al.* (2024)**: The efficacy of pulmonary rehabilitation training program for patients after lung transplantation. Journal of Thoracic Disease, 16: 530–41. https://doi.org/10.21037/jtd-23-1774.
10. **Aline Paula M, Watte G, Guilherme M *et al.* (2023):** Ambulatory oxygen therapy in lung transplantation candidates with idiopathic pulmonary fibrosis referred for pulmonary rehabilitation. https://doi.org/10.36416/1806-3756/e20220280.
11. **Gloeckl R, Halle M, Kenn K (2012)**: Interval versus continuous training in lung transplant candidates: A randomized trial. The Journal of Heart and Lung Transplantation, 31: 934–41. https://doi.org/10.1016/j.healun.2012.06.004.
12. **Langer D, Burtin C, Schepers L *et al.* (2012):** Exercise Training After Lung Transplantation Improves Participation in Daily Activity: A Randomized Controlled Trial. American Journal of Transplantation, 12: 1584–92. https://doi.org/10.1111/j.1600-6143.2012.04000.x.
13. **Fuller LM, Button B, Tarrant B *et al.* (2017)**: Longer Versus Shorter Duration of Supervised Rehabilitation After Lung Transplantation: A Randomized Trial. Archives of Physical Medicine and Rehabilitation, 98: 220-226.e3. https://doi.org/10.1016/j.apmr.2016.09.113.
14. **Ulvestad M, Durheim M, Kongerud J *et al*. (2020):** Effect of high-intensity training on peak oxygen uptake and muscular strength after lung transplantation: A randomized controlled trial. The Journal of Heart and Lung Transplantation, 39: 859–67. https://doi.org/10.1016/j.healun.2020.06.006.
15. **Hoffman M, Chaves G, Ribeiro-Samora A *et al.* (2017):** Effects of pulmonary rehabilitation in lung transplant candidates: a systematic review. BMJ Open, 7 (2): e013445. https://doi.org/10.1136/bmjopen-2016-013445
16. **Abidi Y, Kovats Z, Bohacs A *et al.* (2023):** Lung Transplant Rehabilitation—A Review. *Life*, *13*(2): 506. https://doi.org/10.3390/life13020506
17. **Hume E, Ward L, Wilkinson M *et al.* (2020):** Exercise training for lung transplant candidates and recipients: a systematic review. European Respiratory Review, 29 :158. https://doi.org/10.1183/16000617.0053-2020