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The Role of Pulmonary Rehabilitation in Inoperable Advanced Lung Cancer: A Scoping Review

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ABSTRACT

Background: Lung cancer is the leading cause of cancer mortality worldwide. The role of pulmonary rehabilitation (PR) in patients with inoperable advanced lung cancer remains less defined due to disease severity and poor prognosis. This scoping review aims to map the characteristics, implementation methods, outcome metrics, and effectiveness of PR in this specific population.

Methods: A systematic literature search was conducted across PubMed, Web of Science, CINAHL, Embase, Cochrane, and OpenGrey databases up to October 2025, following JBI guidelines and the PRISMA-ScR checklist. Randomized controlled trials and nonrandomized intervention studies focusing on PR for patients with advanced lung cancer were included. The literature was screened and selected according to the PICOS framework, after which data were extracted and organized from the included studies and finally integrated using a narrative synthesis approach.

Results: Thirty-two studies involving 1979 patients were included. Interventions were predominantly hospital-based, and core components included aerobic and resistance training. The intervention period ranged from 2 to 12 weeks, with the intensity primarily being moderate to high. Significant improvements were consistently reported in exercise capacity, muscle strength, and symptom burden. However, evidence regarding lung function and health-related quality of life remained heterogeneous. Completion rates varied from 44% to 100%, with disease progression being a primary barrier to adherence. None of the studies reported any serious adverse events.

Conclusions: PR is a safe and feasible intervention for patients with advanced lung cancer, offering clear benefits in terms of physical function and symptom management. However, maintaining high adherence remains a challenge. Future research should further explore home-based intervention models assisted by digital rehabilitation technologies and actively promote the integration of PR into multidisciplinary palliative care pathways.

1 | Introduction

Lung cancer remains one of the most prevalent malignancies globally and is, by far, the leading cause of cancer-related mortality. In 2022 alone, there were over 2.4 million new cases and 1.8 million deaths worldwide [1]. Histologically, lung cancer is categorized into non-small-cell lung cancer (NSCLC) and small-cell lung cancer (SCLC). NSCLC accounts for approximately 85% of cases; notably, 30%–33% of these patients present with locally advanced disease, while roughly 55% already exhibit distant metastases at diagnosis [2, 3]. SCLC comprises 10%–15% of cases, with 60%–70% of patients diagnosed with extensive-stage disease [4].

The management of advanced lung cancer primarily relies on a multimodal integrated approach, including concurrent chemoradiotherapy, targeted therapy, and immunotherapy. While advancements in treatment modalities have significantly improved survival in advanced NSCLC [5], the 5-year survival rate for extensive-stage SCLC remains dismally low at 1%–2% [6]. Patients face a substantial symptom burden; a study of 13,289 patients with Stage IV NSCLC reported fatigue and dyspnea incidence rates of 84.1% and 67.8%, respectively, within one year of diagnosis [7]. These symptoms are similarly prevalent and burdensome in extensive-stage SCLC [8]. Furthermore, this population endures a severe psychological burden, with the prevalence of depressive symptoms reaching 71.4% [9], potentially limiting the efficacy of targeted therapies and immunotherapies. Regarding physical status, 61.8% of patients with advanced lung cancer experience persistent moderate-to-severe functional impairment, which compromises daily activities, mobility, and self-care abilities [10].

Pulmonary rehabilitation (PR) is a comprehensive intervention for chronic respiratory diseases based on supervised exercise training, often supplemented with respiratory training and adjunctive therapies. Its goal is to ameliorate symptoms, enhance health-related quality of life (HRQoL), and improve exercise capacity and survival [11]. Existing literature suggests PR confers multiple benefits in lung cancer care. Behavioral interventions and exercise therapy can significantly alleviate dyspnea and cancer-related fatigue while enhancing overall quality of life in advanced stages [12, 13]. In the surgical context, preoperative and postoperative training has been shown to strengthen respiratory and peripheral muscle function and reduce pulmonary complications [14, 15].

The primary target population for PR in lung cancer has been postoperative patients. Implementing standardized PR protocols for patients with advanced lung cancer poses inherent challenges due to rapid disease progression and poor prognosis. Consequently, it is crucial to provide clinicians with comprehensive evidence regarding the feasibility and effectiveness of PR in this specific cohort. To this end, we conducted a scoping review to systematically examine the characteristics, assessment metrics, clinical effectiveness, and feasibility of PR for patients with advanced lung cancer, aiming to inform future research and clinical implementation.

2 | Materials and Methods

The study followed a scoping review design, which was conducted according to the updated JBI scoping review guide (2020) and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Scoping Review extension [16, 17]. A review registration template is publicly available on the Open Science Framework (osf.io/6qw7n).

2.1 | Research Question

The research questions of this review were as follows:

1. What are the characteristics of the published studies?
2. What are the specific implementation methods of the published studies?
3. For patients with advanced lung cancer, what are the evaluation indicators for the effect of PR?
4. What is the relevant evidence regarding the acceptability and effectiveness of PR for patients with advanced lung cancer?

2.2 | Search Strategy

A systematic literature search was conducted to identify studies on PR for patients with advanced lung cancer. Databases including PubMed, Web of Science, CINAHL, Embase, Cochrane, and OpenGrey were searched for publications up to October 2025. Additional studies were identified by manual screening of reference lists. Taking the PubMed database as an example, the specific search strategy is presented in Supporting Table 1.

The PICOS search strategy was conducted in each database on the basis of the following criteria:

1. Population: Patients with advanced lung cancer (Stage III-IV NSCLC or extensive-stage SCLC).
2. Intervention: PR, defined as single or multimodal interventions including at least one component of aerobic exercise, resistance training, or respiratory training. Adjunctive components such as psychological support, nutritional management, disease education, and behavioral change were also included.
3. Control: To evaluate the efficacy of PR on patients with advanced lung cancer, the control group can be either a conventional intervention group or a self-control group before and after the intervention.
4. Outcome: Exercise capacity, muscle strength, HRQoL, dyspnea, lung function, mental status, adverse effects, or compliance.
5. Study type: Randomized controlled trials (RCTs) or non-randomized intervention studies.

2.3 | Study Selection

After removing duplicate literature using the literature management tool (EndNote V.X9), two authors (HY and ZF) independently screened the titles and abstracts of the literature. Finally, based on the inclusion/exclusion criteria, the two authors would meet to determine the eligibility of the literature and review the full texts of the remaining literature to determine which ones would be included in the review. Articles that did not provide an English version, were not full-text articles (only conference abstracts), and were not peer-reviewed articles (such as letters, editorials, and newspaper) were excluded. If there were disagreements or uncertainties between the two authors, a group discussion with the third author (FLJ) would be held to reach a consensus.

2.4 | Data Extraction and Synthesis

The two authors independently extracted the data from the included full texts (HY and ZF). This study created an Excel table for data extraction based on the recommendations in the JBI Evidence Synthesis Manual and the TIDieR checklist (Template for Intervention Description and Replication). The table contents included author, publication year, country, research design, sample size, participant type, and key findings. It also included detailed intervention content: what (components and description), who provided and how, where and when, tailoring, and how well (actual/planned). The included articles were equally distributed by the

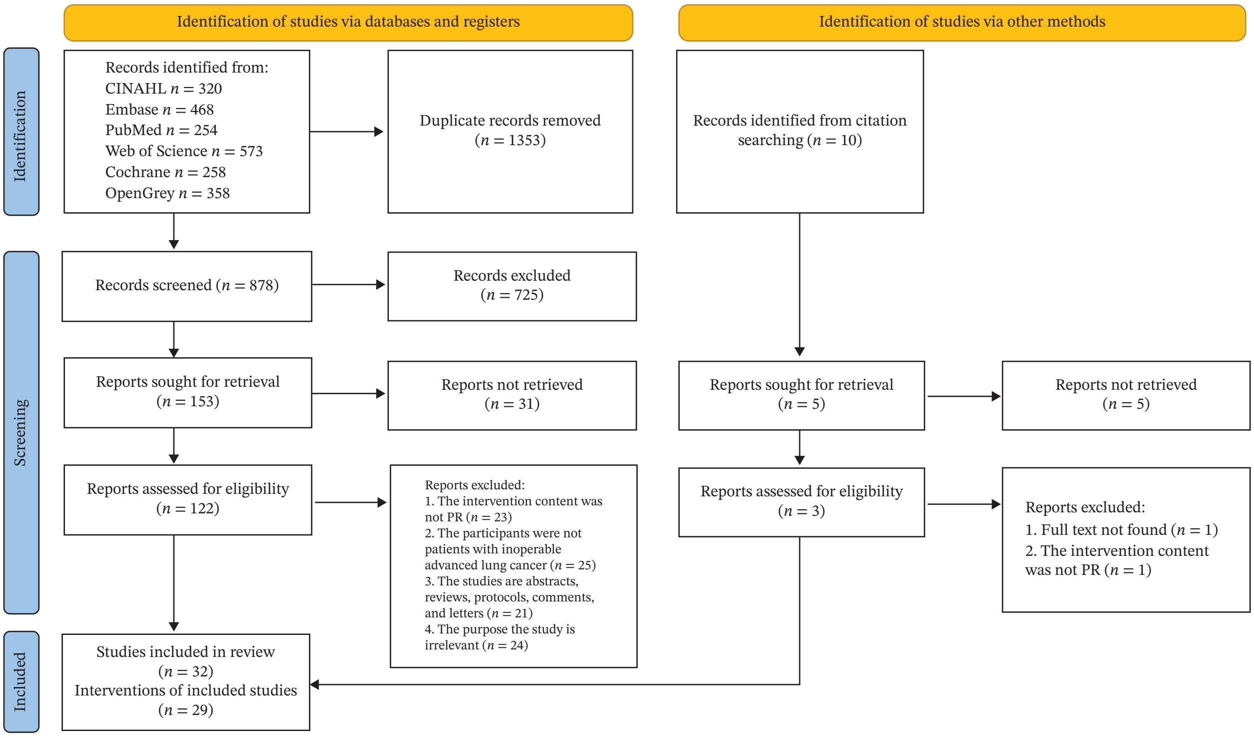

FIGURE 1 | Flow diagram of study selection.

two authors (HY and ZF). The first author was responsible for data extraction, and the second author verified the extracted data, and vice versa (rather than independently extracting all the data). Finally, the data were integrated using a narrative synthesis method.

3 | Results

3.1 | Search Results

A total of 2231 studies were retrieved, and 878 were left after duplication, 153 were left after the title and abstract were read, and 32 were included after the full texts were read, as detailed in the PRISMA diagram (see Figure 1). The 32 studies included in this review comprised of 13 RCTs [18–30], 5 nonrandomized controlled trials [12, 13, 31–33], and 14 pre–post studies [34–47]. The largest number of studies originated from China [13, 20, 23, 29, 30] and Denmark [18, 24, 26, 39, 40] ($n = 5$, respectively). The origins of the other studies included Canada [34, 38, 41], Poland [21, 22, 33], and USA [37, 44, 47] ($n = 3$, respectively), Australia [25, 27], Germany [28, 45], Japan [12, 35], Korea [19, 42], and Turkey [28, 46] ($n = 2$, respectively), and Italy [31], Thailand [32], and France [43] ($n = 1$, respectively). A total

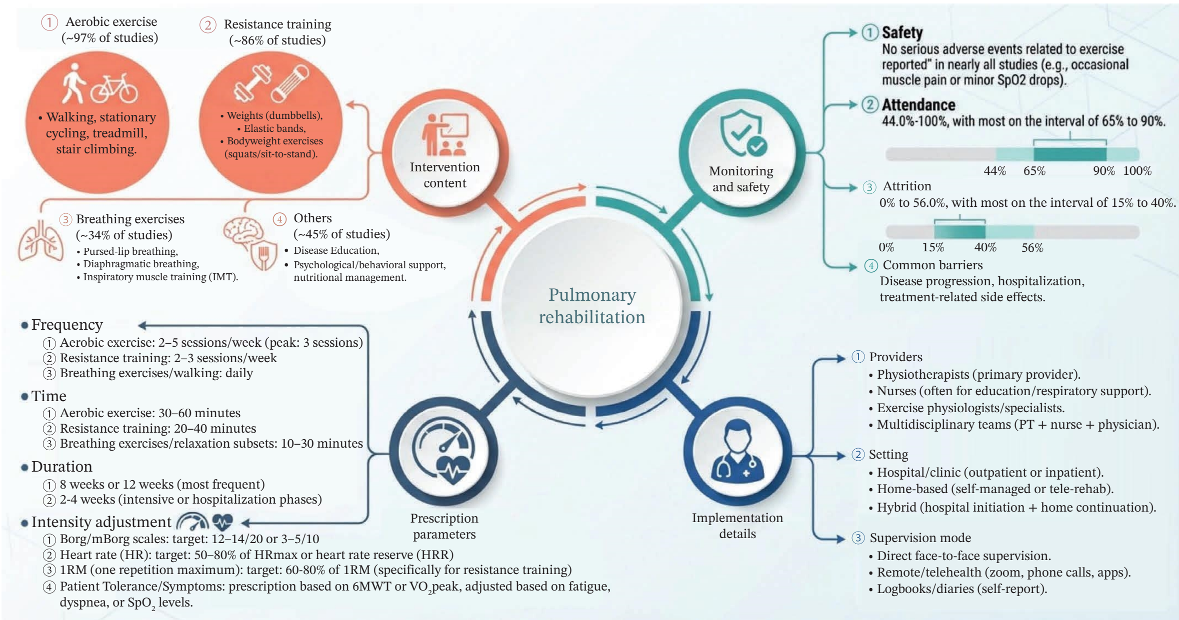

FIGURE 2 | Key components and prescription parameters of pulmonary rehabilitation for advanced lung cancer.

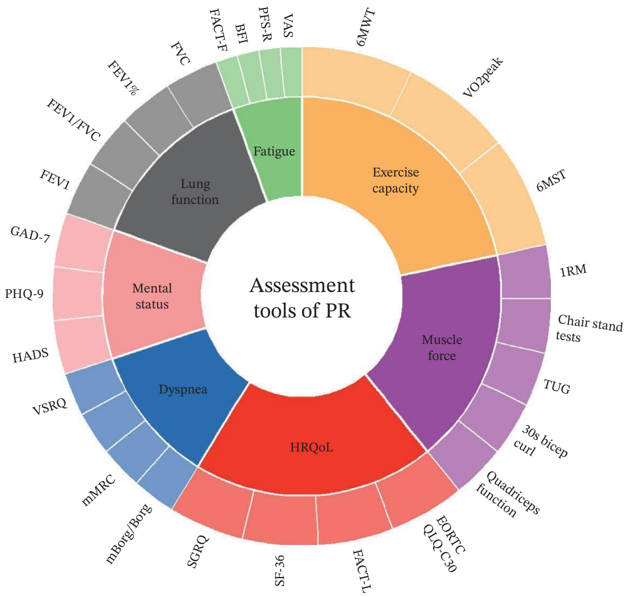

FIGURE 3 | Assessment tools of pulmonary rehabilitation for patients with advanced lung cancer. 6MWT: six-minute walk test. 6MST: six-minute stepper test. VO_2peak: peak oxygen uptake. 1RM: one-repetition maximum. TUG: timed up and go test. FEV1: forced expiratory volume in one second. FVC: forced vital capacity. HRQoL: health-related quality of life. EORTC QLQ-C30: European organization for research and treatment of cancer quality of life questionnaire core 30. FACT-L: functional assessment of cancer therapy-lung. SF-36: 36-item short form health survey. SGRQ: St. George's respiratory questionnaire. mMRC: modified medical research council dyspnea scale. mBorg: modified borg scale. VAS: visual analog scale. VSRQ: Visual simplified respiratory questionnaire. HADS: hospital anxiety and depression scale. PHQ-9: patient health questionnaire-9. GAD-7: generalized anxiety disorder-7. FACT-F: functional assessment of cancer therapy-fatigue. BFI: brief fatigue inventory. PFS-R: piper fatigue scale-revised.

of 1979 patients with Stage III-IV NSCLC or extensive SCLC were included in the study, with sample sizes ranging from 5 to 226 for each study. The detailed study characteristics are displayed in Supporting Table 2.

3.2 | Characteristics of PR

Among the 32 included studies, two of them had their intervention content carried out by a research team [21, 22], and three of them had their intervention content also carried out by a research team [24, 39, 40]. Therefore, this article has comprehensively summarized a total of 29 interventions. In addition to the exercise training ($n = 28$) and/or breathing exercises ($n = 10$), some studies incorporated other interventions such as psychological support [18, 24, 30, 37, 43, 44], nutritional management [13, 38, 42], disease education [13, 30, 32, 38, 41–43], and behavior change strategies [25, 27]. The overview of the PR content included in the study is shown in Figure 2, and the detailed content is presented in Supporting Table 3.

Exercise training primarily included aerobic exercise, resistance training, and flexibility exercises, with some studies including tai chi [20, 23]. Aerobic activities mainly consisted of walking (brisk/treadmill/outdoor) [19, 24, 25, 28, 31, 34–36, 43, 45, 47], stationary cycling/cycle ergometer [13, 20, 23, 24, 26, 29, 33, 45, 47], stair climbing [13, 28, 43], and Nordic walking [21, 33]. Exercise intensity was generally regulated using the Borg/mBorg scales and maximum heart rate, with most studies maintaining an intensity between 50% and 80% of maximum heart rate (or heart rate reserve) and/or a Borg score of 12–14/20 or an mBorg score of 3–5/10. Aerobic sessions typically lasted 30–60 min, often around 45 min including warm-up and cool-down stretching/relaxation. The frequency ranged from approximately 2 to 5 sessions per week, with 3 sessions being the most common. Resistance training targeted major upper and lower limb muscles (legs, chest, back, shoulders, and arms) and core muscles. Equipment used included resistance bands [13, 19, 20, 34, 37, 38, 41, 43, 45] and body weight [19, 31, 35, 36, 38, 45, 46]. Intensity was prescribed based on the Borg/mBorg scales and percentage of one-repetition maximum (1RM), with most programs using 60%–80% of 1RM. Resistance sessions generally lasted 20–40 min and were performed 2-3 times per week, often on alternate days from aerobic training. Breathing exercises included techniques such as pursed-lip breathing [13, 19, 21, 32, 36, 44, 46] and diaphragmatic breathing [19, 36, 44, 46]. These were typically conducted for 10–30 min, often as part of a comprehensive session, and were practiced daily (e.g., 2-3 times per day) or integrated into most exercise sessions.

Interventions were delivered in various settings: hospital/outpatient clinic [12, 13, 18, 21, 26, 28–30, 33, 36, 44, 46, 47], home-based [19, 25, 31, 35, 41–43], online platforms such as Zoom [34], hybrid (hospital + home) [24, 27, 32, 37, 38, 45], and other specialized venues [20, 23]. The providers were physiotherapists [12, 18, 19, 21, 24–26, 28, 29, 31, 36, 37, 43, 47], nurses [18, 25, 30, 32, 43, 44], clinical exercise physiologists [18, 25, 30, 32, 43, 44], rehabilitation professionals [13], and tai chi masters [20, 23]. Supervision methods encompassed on-site monitoring [12, 18–21, 24–26, 28, 29, 36, 37, 43, 45, 47], remote real-time video supervision [34, 41], weekly telephone follow-ups [13, 31, 45], training diary reviews [13, 19, 24, 35], and sensor-based monitoring (e.g., heart rate and SpO_2) [19, 41]. The duration of interventions in the included studies ranged from 2 to 12 weeks, with 8 weeks and 12 weeks being the most common.

3.3 | Outcomes of PR

The six-minute walk test (6MWT) was the predominant measure of functional exercise capacity [13, 20, 22–28, 31, 33–36, 39–43, 45–47]. Peak oxygen uptake (VO_2peak), assessed via cardiopulmonary exercise testing [13, 24, 26, 29, 39–41], served as the gold standard for evaluating integrated cardiopulmonary endurance. Muscle strength was commonly measured using the 1RM test [24, 25, 28, 29, 39, 40, 45, 47], time-to-go (TUG) test [22, 23, 34, 37, 41, 43, 45], and chair stand tests [20, 22, 23, 28, 34, 35, 43, 45]. Pulmonary function was primarily assessed through spirometry, with FEV1 and FVC being the most frequently reported parameters [13, 19, 22, 24, 26, 27, 31, 33, 46]. The Functional Assessment of Cancer Therapy-Lung scale (FACT-L) [21, 24–26, 34, 39–41, 44–47] and the European Organization for Research and Treatment of Cancer Quality of Life Questionnaire (EORTC QLQ) [13, 18, 20, 23, 27–29, 36, 38, 41, 42, 47] were the most utilized tools for assessing HRQoL. Dyspnea was most often rated using the modified Medical Research Council (mMRC) scale [13, 22, 33, 44, 46] or Borg/mBorg Scales [12, 22, 28, 31, 36]. The Hospital Anxiety and Depression Scale (HADS) was the most widely employed instrument for evaluating symptoms of anxiety and depression [20, 23, 24, 26, 39, 43, 44, 47]. The indicators for PR outcomes of patients with advanced lung cancer are shown in Figure 3.

A majority of studies demonstrated statistically significant improvements in 6MWT [20, 23, 24, 26, 39, 43, 44, 47] and muscle strength [20, 23, 24, 26, 39, 43, 44, 47] following the intervention. Significant reductions in dyspnea [12, 13, 20, 22, 28, 29, 31–33, 36, 44] and cancer-related fatigue [13, 29, 36, 42] were among the most frequently reported symptoms. Studies consistently reported significant reductions in anxiety and depression [20, 24, 39, 43, 44]. While improvements in HRQoL scores were variable, significant positive changes were consistently found in vital subdomains, including physical functioning, symptom burden, and emotional well-being [12, 13, 18, 20, 22–25, 28, 29, 31–34, 36, 38–40, 42–44]. Improvements in VO_2peak [13, 29, 39, 40] were more consistently reported than changes in spirometric values. Some studies showed significant gains in lung function [13, 19, 22, 33], while others did not [26, 27, 31, 41, 46].

The range of attendance is between 44.0% and 100%, with most studies focusing on the interval of 65%–90%. The range of attrition is between 0% and 56.0%, with most studies concentrating on the interval of 15%–40%. Common reasons for missed sessions or dropout included disease progression, hospitalization, treatment-related side effects, and competing medical appointments. The vast majority of studies explicitly reported no serious adverse events related to the exercise interventions. Minor, transient events were occasionally noted, such as brief oxygen desaturation that resolved with intensity adjustment or musculoskeletal soreness. These events did not lead to serious harm and were managed appropriately within the study protocols.

4 | Discussion

A review of 32 studies on PR in patients with advanced lung cancer demonstrated that aerobic exercise and resistance training remain core components of the intervention. The intervention is mainly implemented in hospital and supervised by physical therapists. Each training session typically runs about 60 min, spanning 2–12 weeks. In terms of effects, most evidence supports that PR improves exercise capacity and muscle strength and alleviates symptoms such as dyspnea, fatigue, anxiety, and depression. However, the impact on lung function and overall HRQoL varies among different studies.

Fear of exacerbating breathlessness often leads patients to adopt a sedentary lifestyle, particularly avoiding high-intensity activities. This avoidance triggers a "dyspnea–inactivity spiral" [48], where reduced physical activity accelerates functional decline, which in turn intensifies respiratory distress. But evidence indicates that postexercise dyspnea in patients with Stage III-IV thoracic cancer is typically transient—resolving within approximately 4 minutes of rest [49]. This aligns with our study results that PR is feasible and safe for patients with advanced lung cancer. At any stage of treatment, patients can tolerate interventions of moderate to high intensity. In addition, PR does not aggravate respiratory symptoms but rather mitigates them, maintaining a high safety profile with no severe intervention-related adverse events.

Despite the clear advantages of PR, its broad adoption among patients with advanced lung cancer faces significant barriers. Our synthesis highlights a concerning variability in adherence, with completion rates dropping as low as 44%. Notably, 82.8% of included studies focused on isolated exercise training or exercise plus another intervention. Relying solely on exercise may be excessively burdensome for patients with high symptom clusters, making long-term sustainability difficult [30]. To overcome these barriers, we propose that PR should be transitioned from a standalone intervention to an integrated component of the palliative care pathway. Future protocols must adopt a multidisciplinary approach—combining exercise with respiratory training, nutritional support, symptom management, and psychological care—tailored to the patient's fluctuating functional status [50, 51]. What is important is that, rather than avoiding high-intensity training, interdisciplinary collaboration is essential to define safe intensity thresholds that maximize therapeutic gain without compromising patient tolerance [52].

The evaluation of PR efficacy in advanced lung cancer typically encompasses exercise capacity, muscle strength, and HRQoL. However, synthesizing these outcomes into a cohesive assessment of effectiveness remains challenging. The severe destruction of alveolar structure and pulmonary microvessels in patients with advanced lung cancer often imposes a "physiological limit" on the recovery of lung function [53, 54]. Consequently, parameters such as FEV1 may not have significant changes postintervention, limiting their utility as reliable indicators of PR success in this specific population [55]. Furthermore, HRQoL assessment tools may lack the necessary sensitivity to detect the subtle clinical improvements that occur in patients with severe symptoms. In clinical practice, it is more important to consider the minimal important differences (MIDs) of changes in HRQoL, so as to provide a threshold reference for nursing management in palliative care and optimize the allocation of resources for supportive care [56].

Integrating PR into the care of patients with advanced cancer has a profound impact on their functional survival. However, long-term adherence remains a formidable challenge. To address this, home-based and hybrid models are emerging as viable alternatives to hospital-based intervention [19, 34, 35, 37]. However, the safety of remote training remains a critical issue that needs to be addressed urgently. While evidence suggests that cancer survivors can generally initiate low-impact aerobic activities (e.g., walking or cycling) and progressive resistance training without exhaustive medical clearance [57], high-intensity protocols require a rigorous preexercise evaluation of health factors, acute symptoms, comorbidities, and cardiovascular medications [58]. The integration of remote monitoring and sensor technologies—such as real-time SpO_2 tracking and video-mediated supervision—not only enhances service accessibility but also provides a necessary safety net for home-based interventions [59, 60]. Future research should prioritize the development of standardized telehealth frameworks that ensure safety while empowering patients with advanced lung cancer to maintain effective, home-based PR routines.

4.1 | Study Limitations

This review has certain limitations. Firstly, the research designs included in this review are highly heterogeneous, including RCTs, nonrandomized controlled trials, and single-group pre–post studies, which limits the possibility of conducting a meta-analysis of the intervention effects. Secondly, some studies have a small sample size (the minimum being only 5 individuals), which may lead to selection bias. Finally, most studies lack long-term follow-up data, and the long-term benefits and cost-effectiveness ratio of PR in patients at the end of their lives remain unclear.

5 | Conclusion

PR is safe and effective for patients with advanced lung cancer, significantly improving their physical function and symptom management. However, the high dropout rate indicates that we need a flexible delivery model and interdisciplinary intervention contents. Future research should focus on how to deeply integrate PR into the palliative treatment pathway for advanced lung cancer, improve compliance through remote medical means, and further verify its long-term value in prolonging patients' survival and improving their quality of life.

Author Contributions

H.Y. and Z.F. contributed to study design, literature search, and data collection. H.Y. and F.L. contributed to writing of the manuscript draft. Critical manuscript revision was performed by Z.F. and F.L.

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Disclosure

All authors approved this version.

Ethics Statement

The authors have nothing to report.

Consent

The authors have nothing to report.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

Data sharing is not applicable to this article as no datasets were generated or analyzed during the current study.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section.
Supporting Information 1. Supporting Table 1: PubMed search strategy for pulmonary rehabilitation in advanced lung cancer.
Supporting Information 2. Supporting Table 2: The basic characteristics of the studies included in this scoping review.
Supporting Information 3. Supporting Table 3: Description of the interventions using a modified version of the TIDieR checklist.