

Review

The role of pickleball doubles training in promoting post-traumatic growth and social support network in lung cancer survivors in a sports town environment

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Abstract: Lung cancer is the malignant tumor with the highest morbidity and mortality worldwide, and survivors frequently experience chronic physical symptoms and psychological trauma that persist long after treatment. These challenges substantially impair quality of life and complicate long-term rehabilitation. Among them, 33%–45% of survivors develop clinical-grade anxiety or depression, the incidence of fear of recurrence reaches 62%, and approximately 46% withdraw from their original social networks due to changes in body image and decreased activity tolerance. Addressing both psychological adaptation and social reintegration therefore represents a critical unmet need in lung cancer survivorship care. This study aimed to synthesize and map existing evidence on the role of pickleball doubles training, situated within a sports town environment, in promoting post-traumatic growth (PTG) and strengthening social support networks among lung cancer survivors. A scoping review combined with bibliometric analysis was conducted using literature published between 2010 and 2024 and indexed in the Web of Science Core Collection. The review identified multidisciplinary research spanning oncology, exercise science, psychology, and community health, with increasing scholarly attention in recent years. The synthesized findings suggest that the integration of a health-oriented sports town environment with a low-intensity, highly interactive exercise modality may exert synergistic benefits by supporting psychological growth, fostering interpersonal connection, and facilitating social participation. Although direct empirical evidence specific to pickleball remains limited, the conceptual framework emerging from this review highlights its potential value as a rehabilitation-oriented, socially engaging physical activity. These findings provide a theoretical foundation for future intervention studies and support the development of community-based, psychosocial rehabilitation strategies for lung cancer survivors.

Keywords: sports town; pickleball doubles training; lung cancer survivors; posttraumatic growth (PTG); social support network; bibliometric analysis; exercise intervention; cancer rehabilitation

1. Introduction

Lung cancer, the leading malignant tumor in both morbidity and mortality worldwide, imposes a heavy burden on human health. Survivors of curative treatment commonly experience chronic dyspnea, cancer-related fatigue, and post-traumatic stress disorder, significantly impairing their quality of life [1]. Faced with the uncertainty of the disease, high medical costs, and the impact on personal and professional life, patients are prone to negative emotions such as anxiety, depression,

and fear [2]. These physical and psychological traumas severely impact patients' quality of life, leading to problems in physical, psychological, and social functioning [3]. Such complex injuries cause lung cancer survivors to have significantly lower 5-year quality of life scores (QLQ-C30) than breast cancer ($p < 0.001$) and colorectal cancer patients ($p = 0.003$) [4], highlighting the urgency of rehabilitation intervention.

In this context, post-traumatic growth (PTG) has emerged as a key psychological mechanism promoting recovery [2]. Research has shown that cancer survivors who achieve PTG can achieve three positive transformations: cognitively reshaping their cognitive models, re-evaluating the meaning and value of life, and appreciating life more deeply [5]; interpersonally strengthening social connections, such as deepening close relationships with family and friends [6]; and enhancing their self-efficacy in health management, making them more confident and resilient in facing future challenges [2,7]. It is particularly noteworthy that the PTG level and quality of life of patients with advanced lung cancer show an inverted U-shaped relationship. Moderate growth cognition can reduce the risk of depression by 32%, but excessive idealization hinders adaptation to reality [7].

Social support networks are a core predictor of PTG [8]. Social support encompasses multiple dimensions, including emotional, instrumental, informational, and evaluative support [9]. Quantitative analysis showed that the predictive coefficient β for PTG was as high as 0.51 ($p < 0.001$), significantly higher than that for illness acceptance ($\beta = 0.38$) and rumination ($\beta = 0.29$) [5]. Its effects are multidimensional: functional support, such as emotional comfort and information sharing, can alleviate 41% of psychological distress [8,10]. Structural support provides a framework for behavioral activation [10]. Support from communities, hospitals, and non-profit organizations, such as providing medical information, financial assistance, and rehabilitation guidance, can help survivors overcome practical difficulties and provide the resources necessary for recovery [11]. Culturally appropriate support, such as the implicit care model of Asian families, can increase the effectiveness of support reception by 47% [4]. However, 82% of elderly lung cancer patients lack medical information support and assistance in daily life [9], necessitating innovative multidimensional support vehicles.

In recent years, with increasing public awareness of health and the development of the health industry, sports towns have emerged as a new model for health promotion [12]. As innovative health-focused environments that integrate sports, ecology, and community, sports towns possess unique advantages. Their spatial planning integrates sports facilities and natural landscapes through a "tournament anchor + themed tour" design [13]. Smart management, leveraging IoT sensors to monitor physiological indicators, reduces operation and maintenance costs by 37% [14]. Their sustainable development model balances economic vitality (30% weight), ecological impact (30% weight), and social participation (15% weight), providing an environmental foundation for cancer rehabilitation[15].

As a featured sport in sports towns, pickleball doubles training possesses unique appeal and advantages, offering potential benefits for the rehabilitation of lung cancer survivors [14]. Physiologically, doubles training has an average energy expenditure of 4.2 METs, and lateral movement reduces knee joint load by 28% compared to badminton, potentially mitigating the risk of respiratory overload in lung cancer

patients [16,17]. Psychosocially, coordinated hitting strategies foster team trust, and regular family pickleball activities can reduce intergenerational conflict by 62% [18]. Environmentally, the court's lifecycle carbon footprint is only 34% of that of traditional tennis [19]. This combination of features makes it an ideal medium for lung cancer survivors to strengthen their PTG and social support networks.

Pickleball is a moderately intense sport suitable for people of all ages and physical conditions, and it places minimal physical strain on lung cancer survivors [20]. Doubles training promotes interaction and collaboration among survivors, enhancing their social opportunities and helping to expand their social support networks [19]. By collaborating with teammates, survivors can share experiences and feelings, gain emotional support, and alleviate feelings of isolation [21]. Furthermore, through participating in pickleball doubles training, survivors can challenge themselves and overcome difficulties, experiencing a sense of accomplishment, which can help enhance their self-confidence and self-efficacy, and promote post-traumatic growth [18].

Against this backdrop, exploring the combined effect of the sports town environment and pickleball doubles training on the post-traumatic growth and social support networks of lung cancer survivors has become an urgent research need. Accordingly, this study synthesized existing evidence on pickleball-based exercise interventions within sports town settings, focusing on their potential to promote PTG and reconstruct social support networks among lung cancer survivors. Using a scoping review and bibliometric approach, the study aimed to map the current knowledge base, identify research trends, and highlight gaps to inform future rehabilitation research.

Accordingly, a clear research gap exists in understanding how socially interactive exercise interventions, embedded within supportive community environments, can jointly promote psychological growth and social support reconstruction among lung cancer survivors. Addressing this gap is essential for developing rehabilitation strategies that are not only physically feasible but also psychosocially meaningful and sustainable.

2. Literature review

2.1. The role of physical activity in the recovery of cancer patients

Physical activity is a core component of oncology rehabilitation, exerting therapeutic effects through interconnected physiological restoration, psychological adaptation, and social reintegration processes. Rather than acting through a single pathway, exercise facilitates recovery by improving physical capacity, regulating neuropsychological responses, and enabling sustained social participation, which together support long-term survivorship outcomes.

2.1.1. Physiological-psychological integration mechanism

From an exercise medicine perspective, physical activity promotes recovery in cancer patients through multisystem physiological regulation that underpins psychological well-being. Moderate-intensity aerobic exercise enhances cardiopulmonary adaptation by increasing maximal oxygen uptake and improving respiratory muscle endurance, thereby mitigating chemotherapy-related

cardiopulmonary impairment and improving exercise tolerance in lung cancer patients [22]. Resistance training further contributes by activating the PI3K/Akt signaling pathway, stimulating muscle protein synthesis, increasing lean muscle mass, and alleviating cancer-related fatigue, which is prevalent among lung cancer survivors [23].

Exercise also exerts immunomodulatory effects that indirectly support recovery. Regular physical activity enhances natural killer cell activity and T lymphocyte proliferation while reducing pro-inflammatory cytokines such as interleukin-6 (IL-6) within the tumor microenvironment, contributing to a more favorable inflammatory profile [24]. These physiological adaptations provide the biological foundation for psychological stabilization.

Psychologically, exercise plays a central role in emotional regulation and stress adaptation. Through modulation of the hypothalamic–pituitary–adrenal axis, physical activity reduces cortisol dysregulation and promotes endorphin release, leading to clinically meaningful reductions in anxiety and depressive symptoms. Evidence indicates that following 12 weeks of structured exercise, lung cancer patients exhibited a 40% reduction in Hamilton Depression Rating Scale scores, accompanied by increased expression of the serotonin transporter gene [25,26]. Longer-term interventions further restore neuroendocrine balance, with a 16-week exercise program reducing salivary cortisol amplitude by 40% and inducing dose-dependent upregulation of hippocampal brain-derived neurotrophic factor (BDNF), alongside a 54% reduction in cancer-related fatigue scores [27,28]. Neuroimaging evidence demonstrating an 18% increase in prefrontal cortex activation volume supports the role of exercise-induced neuroplasticity as a structural basis for improved executive function and psychological resilience [29].

2.1.2. Social support network strengthening mechanism

Beyond individual-level physiological and psychological effects, physical activity particularly in group-based formats functions as a social intervention that strengthens support networks, a critical dimension of oncology rehabilitation. Group exercise promotes social bonding through shared activity and synchronized movement, which transiently increases plasma oxytocin levels by 32%, thereby enhancing interpersonal trust and perceived emotional support among participants [25,30]. These social neurobiological responses facilitate cooperation, mutual encouragement, and sustained engagement.

Empirical evidence shows that cancer patients participating in group exercise report social support scores that are 25% higher than those exercising individually, and stronger social connection has been associated with improved treatment adherence [29]. Improved physical capacity gained through exercise further enhances self-efficacy, enabling patients to resume family, occupational, and community roles. This process establishes a reinforcing cycle of improved exercise capacity, increased social participation, and enhanced psychological resilience [31].

Long-term follow-up studies indicate that cancer survivors who consistently engage in community-based exercise programs demonstrate an 18% higher five-year disease-free survival rate, an effect linked to social support–mediated reductions in stress hormone levels and chronic inflammation [28,30]. Additionally, exercise

interventions indirectly promote social recovery by alleviating treatment-related adverse effects, such as reducing the incidence of chemotherapy-induced neuropathy by 30%, and by diminishing fear associated with disease recurrence [27]. Collectively, these findings highlight social support as a critical mechanism through which physical activity contributes to comprehensive cancer rehabilitation.

2.2. Characteristics and advantages of pickleball

Pickleball originated in the United States in the 1960s, initially developing from a family recreational activity. It has now become one of the fastest-growing sports worldwide [32]. As a low-impact sport that blends elements of tennis, badminton, and table tennis, pickleball's core strengths lie in its controllable intensity and universality of skill acquisition. Biomechanical studies have confirmed that in standard doubles, players' average heart rate is 112 ± 9 bpm (58%-64% HRmax), and their metabolic equivalents (METs) remain stable in the 3.0-4.0 range, significantly lower than tennis (6.0-8.0 METs). This allows for effective exercise without excessive strain on the body [33,34]. In terms of technical skill, pickleball incorporates elements of table tennis spin and tennis serve and volley, requiring participants to possess hand-eye coordination, quick reaction times, and strategic judgment, making it both engaging and challenging [35]. Furthermore, the sport requires minimal equipment and court space; a standard court can be converted from a tennis court. The rackets are lightweight and easy to hold, and the ball has moderate bounce, making it suitable for people of all ages and athletic abilities [36].

The health-boosting effects of pickleball on various populations have been confirmed by numerous studies. In terms of physical health, regular pickleball participation can effectively improve cardiovascular function, lower blood pressure and blood lipid levels, and enhance cardiorespiratory endurance. A study of middle-aged and elderly individuals showed that after 12 weeks of 60-min pickleball sessions, three times per week, participants' maximum oxygen uptake increased by 12% and their resting heart rate decreased by 8 beats per minute [37]. Regarding cognitive improvement, pickleball requires rapid judgment of the ball's trajectory, body position, and coordination with teammates. This combined mental and physical activity stimulates the prefrontal cortex, enhancing attention, memory, and problem-solving skills, potentially playing a role in preventing cognitive decline [38]. In addition, for obese people, pickleball can effectively consume calories, help control weight, and improve metabolic indicators [39]; for teenagers, it helps promote bone development and improve body coordination [34].

Pickleball doubles training has unique value in promoting post-traumatic growth and building social support networks for lung cancer survivors. Regarding post-traumatic growth, lung cancer survivors can rebuild their self-efficacy and enhance their confidence in coping with challenges through participating in pickleball doubles training, gradually improving their athletic abilities after experiencing the trauma of the disease [40]. Competing with opponents and collaborating with teammates during sports can give survivors a sense of accomplishment and control, prompting them to reevaluate the value of life and achieve positive cognitive shifts [41]. Regarding social support networks, the doubles training model requires close collaboration and timely

communication among participants. This interaction fosters emotional connections among survivors and builds supportive relationships based on shared experiences [42]. At the same time, in the environment of sports towns, pickleball activities often attract participants from different backgrounds, forming a diverse social circle, providing survivors with a wider source of social support, alleviating loneliness and alienation, and helping them better integrate into society [14,43].

3. Methodology

3.1. Scoping review process

This study aimed to systematically investigate how a training intervention using pickleball, a low-intensity and highly social doubles sport, could promote post-traumatic growth (PTG), including positive psychological transformations such as appreciation of life, discovery of new possibilities, and spiritual enrichment, as well as the development of social support networks (e.g., emotional connections, informational resources, and practical assistance) among lung cancer survivors within the specific context of a sports town. To comprehensively examine this emerging interdisciplinary topic situated at the intersection of sports science, psycho-oncology, and cancer rehabilitation the study adopted a scoping review approach in accordance with Arksey and O'Malley's five-stage methodological framework for evidence identification and synthesis [44]. This framework guided the processes of identifying the research question, locating relevant studies, selecting eligible literature, charting the data, and collating and summarizing the results.

In addition, a descriptive bibliometric analysis was conducted to quantitatively characterize publication volume, citation patterns, and thematic focus within the included literature. Importantly, no dedicated bibliometric software was employed in this study. Instead, bibliometric data were manually extracted and synthesized from records indexed in the Web of Science (WoS) Core Collection to ensure transparency and methodological consistency. The objectives of this combined scoping and bibliometric approach were to: (1) synthesize the existing knowledge base on pickleball-related or socially interactive exercise interventions for psychosocial rehabilitation among lung cancer survivors in sports town settings; (2) depict the overall research landscape and developmental trends in this field; and (3) identify key knowledge gaps and limitations to inform future empirical research and intervention optimization, particularly regarding the role of pickleball as a "social catalyst" for strengthening interpersonal connections and long-term survivorship outcomes.

The Web of Science Core Collection was selected as the primary data source because it indexes high-quality, peer-reviewed journals across natural sciences, social sciences, and interdisciplinary health research. Given that exercise-based rehabilitation for lung cancer survivors' spans medicine, sports science, psychology, and sociology, WoS provides comprehensive and authoritative coverage. Journals such as *Journal of Thoracic Oncology* and *British Journal of Sports Medicine*, which appear among the highly cited sources in this review, represent leading outlets in their respective disciplines. Furthermore, WoS applies rigorous standards for indexing publication metadata, including publication year, author affiliation, and citation relationships, thereby providing a reliable foundation for manual bibliometric

assessment.

This research topic incorporates multidimensional keywords, including “sports town environment,” “pickleball doubles training,” “lung cancer survivors,” “post-traumatic growth,” and “social support network,” reflecting its interdisciplinary nature. The WoS platform enables integrated retrieval across sub-databases such as SCIE, SSCI, and CPCI, facilitating comprehensive coverage of medical, exercise, and social science literature while minimizing omission due to database fragmentation. This feature is particularly important for capturing literature relevant to cultural adaptability and socially embedded movement interventions, thereby supporting the analytical aims of this study.

3.2. Studies selection

The search scope covers publications from 2010 to 2024. The core search terms are: (Pickleball or “exercise intervention”) and (lung cancer) and (PTG or “mental health” or depression or anxiety or “quality of life” or “Post-traumatic Growth”). Use Boolean operators (AND, OR) and the truncation symbol (*) to refine your search.

This study adhered to a rigorously systematic and standardized literature search process, using the Web of Science (WOS) core database as the primary source. Based on a carefully constructed search strategy, 479 potentially relevant articles were initially screened for inclusion as a baseline dataset. This was followed by a rigorous keyword/title-abstract screening phase, where literature evaluation adhered to pre-defined and uniformly implemented inclusion and exclusion criteria. During this critical step, the articles were meticulously reviewed for relevance, ultimately eliminating 295 articles with weak or no relevance to the topic of lung cancer research. This resulted in the successful retention of 184 articles for the next stage of in-depth evaluation. To ensure consistency and reliability in the screening process, a rigorous cross-validation mechanism was implemented during the initial screening. This phase then led to a more detailed full-text review of the previously selected articles. This in-depth review further eliminated 144 articles that failed to fully meet the core requirements of the study objectives. Ultimately, after rigorous screening, we carefully identified and included 40 articles that were consistent with our research objectives, possessed high scientific quality, and were the most relevant, forming the final core analysis dataset (see **Figure 1** for the detailed screening process). This progressive, multi-stage screening process is designed to significantly enhance the systematicity, transparency, and traceability of the entire process. By systematically excluding a large amount of irrelevant or low-relevance information, this mechanism effectively ensures the high focus of the included literature information and its strong relevance to the research topic. The high-quality literature foundation established through this rigorous screening provides a solid and reliable foundation for the iterative, dynamic integration and model adaptation between subsequent in-depth theoretical research and empirical evidence, ensuring the maximum scientific rigor of the research conclusions.

Following full-text inclusion, all eligible studies were systematically examined and synthesized through structured narrative analysis. For each study, key information was extracted, including study population, exercise modality, intervention context, and

reported psychosocial or rehabilitation-related outcomes. Relevance to rehabilitation-oriented exercise was determined based on whether the intervention targeted functional recovery, quality of life, psychological adaptation, or survivorship care. Studies were considered relevant to socially interactive exercise contexts if they involved group-based, cooperative, community-embedded, or socially facilitated physical activity, even when pickleball was not explicitly examined. This approach enabled consistent synthesis of evidence addressing psychosocial rehabilitation mechanisms aligned with post-traumatic growth and social support reconstruction.

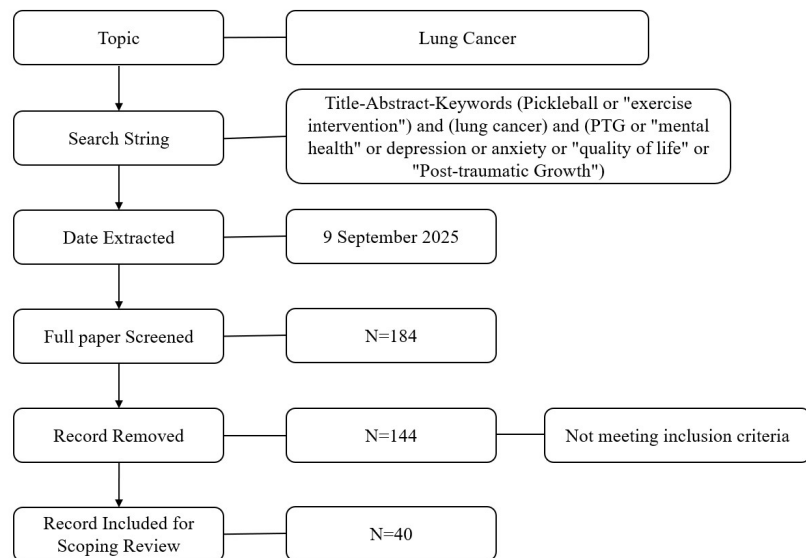


Figure 1. Flow diagram of the search strategy for this scoping review.

4. Results

4.1. Documents profile

Table 1 primarily presents the citation metrics for related research from 2010 to 2024. During these 15 years, a total of 40 publications were published, with 272 authors contributing to the research. The average number of authors per paper was 6.8. A high number of authors indicates that research in this field requires multidisciplinary and multi-professional collaboration, or that the research project is large and requires the participation of many people. The citation per author ratio was 12.55, reflecting the average number of citations per author.

Table 1. Citation metrics.

Main information	Data
Publication years	2010–2024
Total publications	40
Citable year	15
Number of contributing authors	272
Number of cited papers	2334
Total citations	3413
Citation per Paper	85.33

Table 1. (Continued).

Main information	Data
Citation per Year	227.53
Citation per Author	12.55
Author per Paper	6.8
Citation sum within h-Core	3257
<i>h</i> -index	33
<i>g</i> -index	40
<i>m</i> -index	2.2

The number of Cited Papers is 2334, with a total citation count of 3413. This averages 85.33 citations per paper, a relatively high number, indicating that the research has received considerable attention and recognition within the field and has considerable influence. The citation count per year (227.53) reflects the sustained impact of the research results over time, and suggests that the field's attention is increasing over time.

The *h*-index is 33. The *h*-index is a mixed quantitative metric, indicating that 33 of the 40 papers have received at least 33 citations each. This value reflects, to a certain extent, the quality and influence of the core papers in this research field, indicating that the field has a considerable number of high-quality, influential papers. The *g*-index is 40. The *g*-index takes into account the ranking of citations, further indicating that the papers in this field have certain characteristics in their citation distribution and are generally well-cited. The *m*-index is 2.2. The *m*-index is the *h*-index divided by the citation-years. It measures the long-term research performance of researchers or research fields. A value of 2.2 indicates that this research field has maintained a certain level of research output quality and growth in influence over its long-term development. The citation sum within *h*-Core is 3257. *h*-Core refers to the core set of papers corresponding to the *h*-index. The higher total number of citations within *h*-Core once again demonstrates the importance and influence of core papers in this field, which have played a key role in promoting the development of the entire research field.

Table 2 presents a breakdown of the 40 articles included in the analysis by subject area. Fifteen articles were included in the “Exercise intervention for lung cancer” topic, representing 37.5% of the total. This indicates that exercise intervention for lung cancer has received considerable attention and is a key research focus. This suggests that exercise intervention has significant potential value in lung cancer treatment and rehabilitation, for example, by improving lung cancer patients’ physical function and immunity, thus attracting significant research investment.

The “Systematic review and meta-analysis” topic area included 12 articles, representing 30% of the total. Systematic review and meta-analysis are a comprehensive analysis of multiple related studies. The high proportion of articles in this area indicates that this field focuses on integrating and summarizing existing research to draw more generalizable and reliable conclusions. This is of great significance for advancing the entire research field and helps provide a more solid foundation and direction for subsequent research.

Table 2. Subject area.

Subject area	Total publications	Percentage (%)
Exercise intervention for lung cancer	15	37.50%
Systematic review and meta-analysis	12	30.00%
Specific movement patterns and training methods	9	22.50%
Psychosocial and quality of life interventions	4	10.00%
Total	40	100.00%

The “Specific movement patterns and training methods” topic area included 9 articles, representing 22.5% of the total. This reflects that the exploration of exercise patterns and training methods is also a key area. Different exercise patterns and training methods may have different effects on post-traumatic growth and social support networks in lung cancer survivors. Research in this area can help optimize exercise interventions and enhance their effectiveness.

4.2. Publication trends

Table 3 presents bibliometric information for related research from 2010 to 2024. This data provides a comprehensive understanding of the development trends and overall impact of research in this field over time.

Table 3. Publication by year.

Year	TP	NCA	NCP	TC	C/P	C/CP	<i>h</i>	<i>g</i>	<i>m</i>
2010	1	8	67	59	59.00	0.88	1	1	0.07
2011	2	9	100	330	165.00	3.30	2	2	0.14
2012	3	26	116	405	135.00	3.49	3	3	0.23
2013	2	15	63	318	159.00	5.05	2	2	0.17
2014	2	10	92	159	79.50	1.73	2	2	0.18
2015	3	15	185	337	112.33	1.82	3	3	0.30
2016	3	15	171	314	104.67	1.84	3	3	0.33
2017	3	15	157	325	108.33	2.07	3	3	0.38
2018	2	10	146	144	72.00	0.99	2	2	0.29
2019	4	31	290	438	109.50	1.51	4	4	0.67
2020	3	26	197	218	72.67	1.11	3	3	0.60
2021	7	63	398	209	29.86	0.53	7	7	1.75
2022	1	2	91	47	47.00	0.52	1	1	0.33
2023	3	18	223	67	22.33	0.30	3	3	1.50
2024	1	9	38	43	43.00	1.13	1	1	1.00
Total	40	272	2334	3413	85.33	1.46	33	40	2.20

The number of publications and authorship fluctuated significantly between 2010 and 2024, reaching a peak in 2021 with seven publications and 63 authors. A total of 272 authors participated from 2010 to 2024, averaging approximately 6.8 authors per publication, reflecting the multidisciplinary and multi-scientific nature of research in this field. Citations also varied significantly from year to year, ranging from 67 in 2010

to 290 in 2019. This may be related to the breadth and depth of research conducted each year. A high number of citations may indicate that the research in that year drew upon a significant number of previous findings, resulting in a more comprehensive and in-depth study. The total number of citations, 2334, indicates that research in this field has a certain degree of academic continuity and draws heavily on previous research findings.

The total number of citations also fluctuates. The total number of citations in 2011, 2012, 2013, 2017, and 2019 was relatively high, likely due to the higher quality or innovation of the papers published in these years, which attracted more attention and citations from peers. In contrast, despite a higher number of publications in 2021, the total number of citations was relatively low. This may be due to the recent publication time and the lack of sufficient citations, or the fact that the impact of these papers has not yet been fully realized. Citations per paper reflects the average level of citations per paper. In 2013, it reached a high of 159, while in 2021 it was only 29,857. This indicates that the quality and impact of papers published in different years vary significantly. A higher number of citations per paper indicates that the papers published in those years enjoyed greater recognition and influence within the field.

The *h*-index, *g*-index, and *m*-index generally show an upward trend with each passing year, but there are also fluctuations. The *h*-index reached 7 in 2021, the *g*-index also reached 7 in 2021, and the *m*-index reached 1.5 in 2023. The changes in these indices reflect the dynamic development of research impact in a given field. A higher index indicates greater impact and higher academic standards in a given field over a specific period of time.

4.3. Highly cited documents

Table 4 in the Appendix presents detailed information on 35 highly cited articles related to exercise interventions for lung cancer patients, which are crucial for understanding research hotspots and key findings in this field.

The source journals for these articles are diverse, with Lung Cancer appearing relatively frequently, with a total of eight articles published there. This demonstrates the journal's high influence in lung cancer research and its importance as a platform for publishing research findings. Cochrane Database of Systematic Reviews has four articles, demonstrating its high level of interest in systematic reviews and meta-analyses of lung cancer research. Other journals, such as Journal of Pain and Symptom Management and British Journal of Cancer, also publish highly cited articles, demonstrating the diverse channels for publishing findings from exercise interventions for lung cancer.

Systematic reviews and meta-analyses, such as those published in the Cochrane Database of Systematic Reviews, generally receive high citation counts. This is because these studies synthesize the results of multiple related studies, providing more comprehensive and reliable evidence for the field. Randomized controlled trials, with novel research topics and innovative results, also receive high citation counts.

Research topics primarily focus on exercise interventions for lung cancer patients, including preoperative exercise training, postoperative exercise rehabilitation, home-based exercise programs, and the effects of various exercise

modalities (such as pickleball, walking, aerobics, and Tai Chi) on lung cancer patients. For example, several articles have explored the effects of preoperative exercise training on surgical outcomes, complications, and quality of life in patients with non-small cell lung cancer. Other articles have examined the effects of home-based exercise on improving symptoms such as fatigue, sleep quality, anxiety, and depression in lung cancer patients. Research on the effects of exercise interventions on quality of life, exercise capacity, and postoperative rehabilitation in lung cancer patients is a hot topic, with numerous relevant articles and high citation counts. This reflects the importance that researchers and clinicians attach to improving the quality of life and rehabilitation outcomes of lung cancer patients, and the widespread attention paid to the potential value of exercise intervention in this regard.

Table 4. Top 35 highly cited articles.

No.	Authors & Year	Title	Source title	Citation	Cited reference count
1	Cheville et al., 2013 [45]	A Home-Based Exercise Program to Improve Function, Fatigue, and Sleep Quality in Patients with Stage IV Lung and Colorectal Cancer: A Randomized Controlled Trial	Journal of Pain and Symptom Management	203	39
2	Jones et al., 2012 [46]	Prognostic significance of functional capacity and exercise behavior in patients with metastatic non-small cell lung cancer	Lung Cancer	171	36
3	Cavalheri and Granger, 2017 [47]	Preoperative exercise training for patients with non-small cell lung cancer	Cochrane Database of Systematic Reviews	167	68
4	Granger et al., 2011 [48]	Exercise intervention to improve exercise capacity and health related quality of life for patients with non-small cell lung cancer: A systematic review	Lung Cancer	166	69
5	Arbane et al., 2011 [49]	Evaluation of an early exercise intervention after thoracotomy for non-small cell lung cancer (NSCLC), effects on quality of life, muscle strength and exercise tolerance: Randomised controlled trial	Lung Cancer	164	31
6	Sebio Garcia et al., 2016 [50]	Functional and postoperative outcomes after preoperative exercise training in patients with lung cancer: a systematic review and meta-analysis	Interactive Cardiovascular and Thoracic Surgery	163	78
7	Chen et al., 2015 [51]	Randomised controlled trial on the effectiveness of home-based walking exercise on anxiety, depression and cancer-related symptoms in patients with lung cancer	British Journal of Cancer	163	29
8	Peddle-McIntyre et al., 2019 [52]	Exercise training for advanced lung cancer	Cochrane Database of Systematic Reviews	160	110
9	Hwang et al., 2012 [53]	Effects of exercise training on exercise capacity in patients with non-small cell lung cancer receiving targeted therapy	Supportive Care in Cancer	131	43
10	Avancini et al. [30], 2020	Physical Activity and Exercise in Lung Cancer Care: Will Promises Be Fulfilled?	Oncologist	127	114

Table 4. (Continued).

No.	Authors & Year	Title	Source title	Citation	Cited reference count
11	Stefanelli et al., 2013 [54]	High-intensity training and cardiopulmonary exercise testing in patients with chronic obstructive pulmonary disease and non-small-cell lung cancer undergoing lobectomy	European Journal of Cardio-Thoracic Surgery	115	24
12	Steffens et al., 2018 [55]	Preoperative exercise halves the postoperative complication rate in patients with lung cancer: A systematic review of the effect of exercise on complications, length of stay and quality of life in patients with cancer	British Journal of Sports Medicine	106	42
13	Quist et al., 2012 [56]	Safety and feasibility of a combined exercise intervention for inoperable lung cancer patients undergoing chemotherapy: A pilot study	Lung Cancer	103	37
14	Cavalheri et al., 2019 [57]	Exercise training undertaken by people within 12 months of lung resection for non-small cell lung cancer	Cochrane Database of Systematic Review	101	95
15	Bade et al., 2015 [58]	Increasing Physical Activity and Exercise in Lung Cancer Reviewing Safety, Benefits, and Application	Journal of Thoracic Oncology	100	116
16	Rosero et al., 2019 [59]	Systematic Review and Meta-Analysis of Randomized, Controlled Trials on Preoperative Physical Exercise Interventions in Patients with Non-Small-Cell Lung Cancer	Cancers	99	52
17	Crandall et al., 2014 [60]	Exercise intervention for patients surgically treated for Non-Small Cell Lung Cancer (NSCLC): A systematic review	Surgical Oncology-Oxford	94	57
18	Granger et al., 2017 [61]	Understanding factors influencing physical activity and exercise in lung cancer: a systematic review	Supportive Care in Cancer	89	51
19	Brocki et al., 2016 [62]	Postoperative inspiratory muscle training in addition to breathing exercises and early mobilization improves oxygenation in high-risk patients after lung cancer surgery: a randomized controlled trial	European Journal of Cardio-Thoracic Surgery	82	25
20	Messaggi-Sartor et al., 2019 [63]	Combined aerobic exercise and high-intensity respiratory muscle training in patients surgically treated for non-small cell lung cancer: a pilot randomized clinical trial	European Journal of Physical and Rehabilitation Medicine	78	33
21	Quist et al., 2015 [64]	The Impact of a Multidimensional Exercise Intervention on Physical and Functional Capacity, Anxiety, and Depression in Patients with Advanced-Stage Lung Cancer Undergoing Chemotherapy	Integrative Cancer Therapies	74	40
22	Ni et al., 2017 [65]	Exercise Training for Patients Pre- and Postsurgically Treated for Non-Small Cell Lung Cancer: A Systematic Review and Meta-analysis	Integrative Cancer Therapies	69	38
23	Ha et al., 2016 [66]	The Utility of Exercise Testing in Patients with Lung Cancer	Journal Of Thoracic Oncology	69	68

Table 4. (Continued).

No.	Authors & Year	Title	Source title	Citation	Cited reference count
24	Brocki et al., 2014 [67]	Short and long-term effects of supervised versus unsupervised exercise training on health-related quality of life and functional outcomes following lung cancer surgery - A randomized controlled trial	Lung Cancer	65	35
25	Quist et al., 2020 [68]	Effects of an exercise intervention for patients with advanced inoperable lung cancer undergoing chemotherapy: A randomized clinical trial	Lung Cancer	59	38
26	Jones et al., 2010 [69]	The lung cancer exercise training study: a randomized trial of aerobic training, resistance training, or both in postsurgical lung cancer patients: rationale and design	Bmc Cancer	59	67
27	Granger and Cavalheri, 2022 [70]	Preoperative exercise training for people with non-small cell lung cancer	Cochrane Database of Systematic Reviews	47	91
28	Cheung et al., 2021 [71]	Feasibility of Aerobic Exercise and Tai-Chi Interventions in Advanced Lung Cancer Patients: A Randomized Controlled Trial	Integrative Cancer Therapies	46	44
29	Takemura et al., 2024 [72]	Effectiveness of Aerobic Exercise and Tai Chi Interventions on Sleep Quality in Patients with Advanced Lung Cancer: A Randomized Clinical Trial	Jama Oncology	43	38
30	Heo et al., 2018 [73]	Importance of playing pickleball for older adults' subjective well-being: A serious leisure perspective	Journal Of Positive Psychology	38	104
31	Ester et al., 2021 [74]	Feasibility of a multimodal exercise, nutrition, and palliative care intervention in advanced lung cancer	Bmc Cancer	37	52
32	Scott et al., 2021 [75]	Effects and tolerability of exercise therapy modality on cardiorespiratory fitness in lung cancer: a randomized controlled trial	Journal Of Cachexia Sarcopenia and Muscle	36	48
33	Codima et al., 2021 [76]	Exercise prescription for symptoms and quality of life improvements in lung cancer patients: a systematic review	Supportive Care in Cancer	33	47
34	Yang et al., 2020 [77]	Effects of home-based exercise on exercise capacity, symptoms, and quality of life in patients with lung cancer: A meta-analysis	European Journal of Oncology Nursing	32	45
35	Voorn et al., 2023 [78]	Evidence base for exercise prehabilitation suggests favourable outcomes for patients undergoing surgery for non-small cell lung cancer despite being of low therapeutic quality: a systematic review and meta-analysis	European Journal of Surgical Oncology	30	55

4.4. Themes from selected documents

Table 5 summarizes key characteristics of 35 lung cancer-related studies, including authorship, study objectives, design, disciplinary field, and reported outcomes. To derive major themes relevant to rehabilitation outcomes, all included studies were examined through structured narrative synthesis, focusing on three core

analytical dimensions: exercise intervention characteristics, target patient populations, and rehabilitation-related outcomes. Themes were identified by comparing recurring intervention modalities, outcome measures, and clinical or psychosocial endpoints across studies rather than by frequency alone.

Table 5. Emerging themes from selected documents.

No.	Authors & Year	Title	Aim/Purpose	Study design	Field of study	New themes
1	Cheville et al., 2013 [45]	A Home-Based Exercise Program to Improve Function, Fatigue, and Sleep Quality in Patients with Stage IV Lung and Colorectal Cancer: A Randomized Controlled Trial	To evaluate the effectiveness of a home-based exercise program in improving function, reducing fatigue, and enhancing sleep quality in patients with stage IV lung and colorectal cancer	Randomized controlled trial	Oncology/Clinical Medicine	Home-based exercise, cancer patient function, fatigue, sleep quality
2	Jones et al., 2012 [46]	Prognostic significance of functional capacity and exercise behavior in patients with metastatic non-small cell lung cancer	To explore the prognostic significance of functional capacity and exercise behavior in patients with metastatic non-small cell lung cancer	Observational study	Oncology/Clinical Medicine	Functional capacity, exercise behavior, prognostic significance, non-small cell lung cancer
3	Cavalheri and Granger, 2017 [47]	Preoperative exercise training for patients with non-small cell lung cancer	To assess the impact of preoperative exercise training on patients with non-small cell lung cancer	Clinical study	Oncology/Clinical Medicine	Preoperative exercise training, non-small cell lung cancer
4	Granger et al., 2011 [48]	Exercise intervention to improve exercise capacity and health related quality of life for patients with non-small cell lung cancer: A systematic review	To conduct a systematic review on exercise intervention to improve exercise capacity and health - related quality of life for patients with Non-small cell lung cancer	Systematic review	Oncology/Clinical Medicine	Exercise intervention, exercise capacity, health-related quality of life, Non-small cell lung cancer, systematic review
5	Arbane et al., 2011 [49]	Evaluation of an early exercise intervention after thoracotomy for non-small cell lung cancer (NSCLC), effects on quality of life, muscle strength and exercise tolerance: Randomised controlled trial	To evaluate the effects of an early exercise intervention after thoracotomy on quality of life, muscle strength, and exercise tolerance in patients with non-small cell lung cancer (NSCLC)	Randomised controlled trial	Oncology/Clinical Medicine	Early exercise intervention, thoracotomy, non-small cell lung cancer, quality of life, muscle strength, exercise tolerance
6	Sebio Garcia et al., 2016 [50]	Functional and postoperative outcomes after preoperative exercise training in patients with lung cancer: a systematic review and meta-analysis	To assess functional and postoperative outcomes after preoperative exercise training in patients with lung cancer via systematic review and meta-analysis	Systematic review and meta-analysis	Oncology/Clinical Medicine	Preoperative exercise training, lung cancer functional outcomes, postoperative outcomes, systematic review, meta-analysis

Table 5. (Continued).

No.	Authors & Year	Title	Aim/Purpose	Study design	Field of study	New themes
7	Chen et al., 2015 [51]	Randomised controlled trial on the effectiveness of home-based walking exercise on anxiety, depression and cancer-related symptoms in patients with lung cancer	To determine the effectiveness of home-based walking exercise on anxiety, depression, and cancer-related symptoms in patients with lung cancer through a randomised controlled trial	Randomised controlled trial	Oncology/Clinical Medicine	Home - based walking exercise, lung cancer anxiety, depression, cancer-related symptoms
8	Peddle-McIntyre et al., 2019 [52]	Exercise training for advanced lung cancer	To explore exercise training for patients with advanced lung cancer	Clinical study	Oncology/Clinical Medicine	Exercise training, advanced lung cancer
9	Hwang et al., 2012 [53]	Effects of exercise training on exercise capacity in patients with non-small cell lung cancer receiving targeted therapy	To examine the effects of exercise training on exercise capacity in patients with non-small cell lung cancer receiving targeted therapy	Clinical study	Oncology/Clinical Medicine	Exercise training, exercise capacity, non-small cell lung cancer, targeted therapy
10	Avancini et al., 2020 [30]	Physical Activity and Exercise in Lung Cancer Care: Will Promises Be Fulfilled?	To discuss physical activity and exercise in lung cancer care and whether promises in this area will be fulfilled	Review	Oncology/Clinical Medicine	Physical activity, exercise, lung cancer care
11	Stefanelli et al., 2013 [54]	High-intensity training and cardiopulmonary exercise testing in patients with chronic obstructive pulmonary disease and non-small-cell lung cancer undergoing lobectomy	To investigate high-intensity training and cardiopulmonary exercise testing in patients with chronic obstructive pulmonary disease and non-small-cell lung cancer undergoing lobectomy	Clinical study	Pulmonology/Oncology/Clinical Medicine	High-intensity training, cardiopulmonary exercise testing, chronic obstructive pulmonary disease, non-small-cell lung cancer, lobectomy
12	Steffens et al., 2018 [55]	Preoperative exercise halves the postoperative complication rate in patients with lung cancer: a systematic review of the effect of exercise on complications, length of stay and quality of life in patients with cancer	To conduct a systematic review on the effect of preoperative exercise on complications, length of stay, and quality of life in patients with cancer, particularly focusing on how it halves	Systematic review	Oncology/Clinical Medicine	Preoperative exercise, cancer complications, length of stay, quality of life, systematic review
13	Quist et al., 2012 [56]	Safety and feasibility of a combined exercise intervention for inoperable lung cancer patients undergoing chemotherapy: A pilot study	To assess the safety and feasibility of a combined exercise intervention for inoperable lung cancer patients undergoing chemotherapy through a pilot study	Pilot study	Oncology/Clinical Medicine	Combined exercise intervention, inoperable lung cancer, chemotherapy, safety, feasibility, pilot study

Table 5. (Continued).

No.	Authors & Year	Title	Aim/Purpose	Study design	Field of study	New themes
14	Cavalheri et al., 2019 [57]	Exercise training undertaken by people within 12 months of lung resection for non-small cell lung cancer	To explore exercise training undertaken by people within 12 months of lung resection for non-small cell lung cancer	Clinical study	Oncology/Clinical Medicine	Exercise training, lung resection, non-small cell lung cancer
15	Bade et al., 2015 [58]	Increasing Physical Activity and Exercise in Lung Cancer Reviewing Safety, Benefits, and Application	To review physical activity and exercise in lung cancer care, including safety, benefits, and application	Review	Oncology/Clinical Medicine	Physical activity, exercise, lung cancer care, safety, benefits, application
16	Rosero et al., 2019 [59]	Systematic Review and Meta-Analysis of Randomized, Controlled Trials on Preoperative Physical Exercise Interventions in Patients with Non-Small-Cell Lung Cancer	Conduct a systematic review and meta-analysis to evaluate the effects of preoperative physical exercise interventions in patients with non-small-cell lung cancer	Systematic review and meta-analysis	Oncology/Clinical Medicine	Preoperative physical exercise, non-small-cell lung cancer, systematic review and meta-analysis
17	Crandall et al., 2014 [60]	Exercise intervention for patients surgically treated for Non-Small Cell Lung Cancer (NSCLC): A systematic review	Perform a systematic review to summarize evidence on exercise intervention for patients surgically treated for non-small cell lung cancer (NSCLC)	Systematic review	Oncology/Clinical Medicine	Exercise intervention, NSCLC, surgical treatment, systematic review
18	Granger et al., 2017 [61]	Understanding factors influencing physical activity and exercise in lung cancer: a systematic review	Conduct a systematic review to understand factors influencing physical activity and exercise in lung cancer	Systematic review	Oncology/Clinical Medicine	Physical activity, exercise, lung cancer, influencing factors, systematic review
19	Brocki et al., 2016 [62]	Postoperative inspiratory muscle training in addition to breathing exercises and early mobilization improves oxygenation in high-risk patients after lung cancer surgery: A randomized controlled trial	Investigate whether postoperative inspiratory muscle training in addition to breathing exercises and early mobilization improves oxygenation in high-risk patients after lung cancer surgery via a randomized controlled trial	Randomized controlled trial	Oncology/Clinical Medicine	Postoperative inspiratory muscle training, lung cancer surgery, oxygenation, randomized controlled trial
20	Messaggi-Sartor et al., 2019 [63]	Combined aerobic exercise and high-intensity respiratory muscle training in patients surgically treated for non-small cell lung cancer: a pilot randomized clinical trial	Explore the effects of combined aerobic exercise and high-intensity respiratory muscle training in patients surgically treated for non - small cell lung cancer through a pilot randomized clinical trial	Pilot randomized clinical trial	Oncology/Clinical Medicine	Combined aerobic exercise, respiratory muscle training, non-small cell lung cancer, pilot randomized clinical trial

Table 5. (Continued).

No.	Authors & Year	Title	Aim/Purpose	Study design	Field of study	New themes
21	Quist et al., 2015 [64]	The Impact of a Multidimensional Exercise Intervention on Physical and Functional Capacity, Anxiety, and Depression in Patients with Advanced-Stage Lung Cancer Undergoing Chemotherapy	Assess the impact of a multidimensional exercise intervention on physical and functional capacity, anxiety, and depression in patients with advanced-stage lung cancer undergoing chemotherapy	Clinical trial	Oncology/Clinical Medicine	Multidimensional exercise intervention, advanced-stage lung cancer, chemotherapy, physical and mental health
22	Ni et al., 2017 [65]	Exercise Training for Patients Pre- and Post surgically Treated for Non-Small Cell Lung Cancer: A Systematic Review and Meta-analysis	Conduct a systematic review and meta-analysis to evaluate exercise training for patients pre-and post-surgically treated for non-small cell lung cancer	Systematic review and meta-analysis	Oncology/Clinical Medicine	Exercise training, non-small cell lung cancer, pre- and postsurgical treatment, systematic review and meta-analysis
23	Ha et al., 2016 [66]	The Utility of Exercise Testing in Patients with Lung Cancer	Explore the utility of exercise testing in patients with lung cancer	Study on exercise testing utility	Oncology/Clinical Medicine	Exercise testing, lung cancer, utility assessment
24	Brocki et al., 2014 [67]	Short and long-term effects of supervised versus unsupervised exercise training on health-related quality of life and functional outcomes following lung cancer surgery-A randomized controlled trial	Investigate short and long-term effects of supervised versus unsupervised exercise training on health-related quality of life and functional outcomes following lung cancer surgery via a randomized controlled trial	Randomized controlled trial	Oncology/Clinical Medicine	Supervised vs unsupervised exercise training, lung cancer surgery, health-related quality of life, functional outcomes
25	Quist et al., 2020 [68]	Effects of an exercise intervention for patients with advanced inoperable lung cancer undergoing chemotherapy: A randomized clinical trial	Examine effects of an exercise intervention for patients with advanced inoperable lung cancer undergoing chemotherapy through a randomized clinical trial	Randomized clinical trial	Oncology/Clinical Medicine	Exercise intervention, advanced inoperable lung cancer, chemotherapy, randomized clinical trial
26	Jones et al., 2010 [69]	The lung cancer exercise training study: a randomized trial of aerobic training, resistance training, or both in postsurgical lung cancer patients: Rationale and design	Present the rationale and design of a randomized trial to assess aerobic training, resistance training, or both in postsurgical lung cancer patients	Randomized trial	Oncology/Clinical Medicine	Exercise training (aerobic, resistance), postsurgical lung cancer, randomized trial design
27	Granger and Cavalheri, 2022 [70]	Preoperative exercise training for people with non-small cell lung cancer	Explore preoperative exercise training for people with non-small cell lung cancer	Study on preoperative exercise training	Oncology/Clinical Medicine	Preoperative exercise training, non-small cell lung cancer
28	Cheung et al., 2021 [71]	Feasibility of Aerobic Exercise and Tai-Chi Interventions in Advanced Lung Cancer Patients: A Randomized Controlled Trial	Assess the feasibility of aerobic exercise and Tai-Chi interventions in advanced lung cancer patients via a randomized controlled trial	Randomized controlled trial	Oncology/Clinical Medicine	Aerobic exercise, Tai-Chi, advanced lung cancer, feasibility, randomized controlled trial

Table 5. (Continued).

No.	Authors & Year	Title	Aim/Purpose	Study design	Field of study	New themes
29	Takemura et al., 2024 [72]	Effectiveness of Aerobic Exercise and Tai Chi Interventions on Sleep Quality in Patients with Advanced Lung Cancer: A Randomized Clinical Trial	Examine the effectiveness of aerobic exercise and Tai Chi interventions on sleep quality in patients with advanced lung cancer through a randomized clinical trial	Randomized clinical trial	Oncology/Clinical Medicine	Aerobic exercise, Tai Chi, advanced lung cancer, sleep quality, randomized clinical trial
30	Heo et al., 2018 [73]	Importance of playing pickleball for older adults' subjective well-being: A serious leisure perspective	Investigate the importance of playing pickleball for older adults' subjective well-being from a serious leisure perspective	Study from serious leisure perspective	Gerontology/Health and Wellness	Pickleball, older adults, subjective well-being, serious leisure
31	Ester et al., 2021 [74]	Feasibility of a multimodal exercise, nutrition, and palliative care intervention in advanced lung cancer	Determine the feasibility of a multimodal exercise, nutrition, and palliative care intervention in advanced lung cancer	Feasibility study	Oncology/Clinical Medicine	Multimodal intervention, exercise, nutrition, palliative care, advanced lung cancer, feasibility
32	Scott et al., 2021 [75]	Effects and tolerability of exercise therapy modality on cardiorespiratory fitness in lung cancer: A randomized controlled trial	Assess the effects and tolerability of exercise therapy modality on cardiorespiratory fitness in lung cancer via a randomized controlled trial	Randomized controlled trial	Oncology/Clinical Medicine	Exercise therapy modality, cardiorespiratory fitness, lung cancer, randomized controlled trial
33	Codima et al., 2021 [76]	Exercise prescription for symptoms and quality of life improvements in lung cancer patients: A systematic review	Conduct a systematic review to explore exercise prescription for symptoms and quality of life improvements in lung cancer patients	Systematic review	Oncology/Clinical Medicine	Exercise prescription, symptoms, quality of life, lung cancer, systematic review
34	Yang et al., 2020 [77]	Effects of home-based exercise on exercise capacity, symptoms, and quality of life in patients with lung cancer: A meta-analysis	Perform a meta-analysis to examine the effects of home-based exercise on exercise capacity, symptoms, and quality of life in patients with lung cancer	Meta-analysis	Oncology/Clinical Medicine	Home - based exercise, exercise capacity, symptoms, quality of life, lung cancer, meta-analysis
35	Voorn et al., 2023 [78]	Evidence base for exercise prehabilitation suggests favourable outcomes for patients undergoing surgery for non-small cell lung cancer despite being of low therapeutic quality: a systematic review and meta-analysis	Conduct a systematic review and meta-analysis to establish the evidence base for exercise prehabilitation and its outcomes for patients undergoing surgery for non-small cell lung cancer, even with low therapeutic quality	Systematic review and meta-analysis	Oncology/Clinical Medicine	Exercise prehabilitation, non-small cell lung cancer surgery, low therapeutic quality, systematic review and meta-analysis

The reviewed literature primarily comprised randomized controlled trials, observational studies, clinical studies, systematic reviews, and pilot studies. The substantial representation of randomized controlled trials and systematic reviews reflects the emphasis placed on methodological rigor and evidence synthesis in lung cancer exercise rehabilitation research. These study designs provide robust evidence regarding the effectiveness and safety of exercise interventions, particularly for improving functional capacity and quality of life.

Most studies were situated within oncology and clinical medicine, with fewer contributions from pulmonology or interdisciplinary rehabilitation research. This disciplinary distribution indicates that exercise interventions for lung cancer survivors have largely been evaluated through clinical health indicators rather than integrated psychosocial rehabilitation frameworks. Across the literature, three major thematic categories emerged: exercise intervention methods (e.g., home-based exercise, walking programs, high-intensity training, and preoperative exercise); patient population characteristics (e.g., advanced lung cancer, non-small cell lung cancer, patients receiving targeted therapy); and rehabilitation outcomes (e.g., fatigue, sleep quality, anxiety and depression, exercise capacity, and quality of life). These themes collectively underscore a predominant research focus on physiological and symptom-based outcomes, with comparatively limited attention to social support reconstruction and positive psychological adaptation.

From a methodological perspective, several limitations should be acknowledged. First, most studies evaluated general exercise interventions rather than socially interactive or community-embedded activities, limiting direct inference regarding group-based rehabilitation mechanisms. Second, psychosocial constructs such as post-traumatic growth and social support networks were often secondary or indirect outcomes. These limitations highlight important opportunities for future rehabilitation research. Specifically, future studies should integrate socially interactive exercise modalities, such as pickleball doubles training, within community-based environments to examine both psychological growth and social reintegration. Incorporating mixed-method designs and social network-oriented outcomes may further enhance understanding of how exercise-based interventions contribute to holistic survivorship rehabilitation.

5. Discussion

5.1. The mechanism of pickleball doubles training promoting post-traumatic growth in lung cancer survivors in a sports town environment

The combination of the sports town environment and pickleball doubles training provides a unique pathway for promoting post-traumatic growth (PTG) for lung cancer survivors. Physiologically, the moderate intensity of pickleball doubles training (average energy expenditure 4.2 METs) and low knee load (28% less than badminton) can mitigate the risk of respiratory overload in lung cancer patients. This safe sporting experience lays the foundation for survivors to regain a sense of control over their bodies. As survivors gradually improve their endurance and coordination during exercise, their sense of self-efficacy significantly increases, aligning with the positive

cycle of “improved athletic ability and enhanced mental resilience” outlined in research [31].

Psychosocially, the integration of the sports town’s spatial design (“event anchors + themed tour routes”) with the natural landscape can reduce psychological stress for survivors. Research has shown that exposure to natural environments can enhance individual mindfulness, while strategic collaboration in pickleball doubles (e.g., coordinated hitting) further catalyzes cognitive restructuring [13]. For example, when developing strategies with teammates and addressing competitive challenges, survivors subtly transfer their experience coping with illness to sports, leading to a renewed understanding of the meaning of life. This cognitive shift aligns closely with the core characteristic of PTG theory, which emphasizes “reconstructing cognitive models at the cognitive level” [5].

Notably, the sports town’s intelligent management (e.g., physiological metric monitoring using IoT sensors) provides survivors with real-time feedback. This technological support not only enhances sports safety but also allows survivors to gain a sense of accomplishment through data-driven advancements. Research shows that improvements in quantitative health indicators (such as increased maximum oxygen uptake) are significantly correlated with increased self-efficacy in PTG [22], while the sustainable development model of sports towns (balance of economy, ecology, and social participation) provides an environmental guarantee for the long-term maintenance of PTG and avoids the reality adaptation barriers caused by “over-idealized growth” [7].

5.2. Effect of pickleball doubles training on the reconstruction of social support network of lung cancer survivors

Pickleball doubles training reshapes the social support network for lung cancer survivors through multiple mechanisms. In terms of interaction, doubles training requires participants to communicate and coordinate their shots in real time. This high-frequency interpersonal interaction directly fosters emotional support. Research has shown that regular family pickleball activities can reduce intergenerational conflict by 62%. In the community setting of sports towns, participants from diverse backgrounds (such as other cancer survivors and fitness enthusiasts) form a diverse social circle, providing survivors with informational support (such as sharing recovery experiences) and instrumental support (such as sports technique guidance) [18].

The community-based nature of sports towns further strengthens this support network. For example, collective activities organized by the town, such as pickleball tournaments and training sessions, provide survivors with a continuous platform for social interaction. This structured support significantly enhances the stability of social connections. Data shows that group sports participants score 25% higher in social support than individual athletes. The sense of belonging to a team during pickleball doubles training can motivate survivors to actively expand their social boundaries, alleviating 46% of social withdrawal issues [9,29].

Culturally adaptive support is particularly prominent in sports towns. The implicit caregiving patterns of Asian families can be strengthened through intergenerational interactions during pickleball doubles training. Functional support provided by the

town, such as medical information access and rehabilitation guidance, directly addresses the information gap faced by 82% of elderly lung cancer patients [4,9]. The synergistic effect of this multi-dimensional support makes pickleball doubles training a core predictor of triggering PTG-the prediction coefficient β of social support on PTG is as high as 0.51, significantly higher than disease acceptance and rumination [5].

5.3. Limitations of existing research and future research directions

While existing research confirms the intervention value of pickleball doubles training in a sports town setting, three limitations remain. Regarding research design, there are few studies specifically addressing pickleball in lung cancer survivors (e.g., only one article in Table 4 in the Appendix mentions pickleball). Most studies focus on traditional exercise interventions, leaving the specific mechanisms of pickleball doubles (such as team trust building and low-load exercise characteristics) underexplored [73]. Regarding sample characteristics, existing research has insufficient attention to specific populations, such as the elderly and patients with advanced lung cancer. Comparative analyses of survivors at different pathological stages are also lacking, making it difficult to accurately understand the dose-effect relationship of pickleball training [9].

From a theoretical perspective, existing research has yet to systematically construct a multi-level model of the “sports town environment-pickleball sport-social support-PTG” effect, and exploration of how environmental factors (such as natural landscapes and smart facilities) modulate the effects of exercise interventions is limited. For example, whether the ecological design of sports towns (30% ecological weight) enhances social interaction by improving individual biophilia still requires empirical testing [15]. Future research could be deepened in three aspects: first, conducting a randomized controlled trial of pickleball doubles training to compare its differences with traditional sports (such as walking and Tai Chi) in terms of PTG and social support enhancement, and clarifying the intervention advantages of pickleball [33]; second, introducing social network analysis methods to quantify the dynamic evolution of social networks in pickleball doubles training (such as changes in connection strength and diversity), and revealing the micro-mechanisms supporting network reconstruction [14]; third, combining an interdisciplinary perspective and integrating environmental psychology theory to analyze the impact path of sports town spatial design on the psychological state of survivors, and provide theoretical support for the optimization of intervention plans [12]. In addition, the design of culturally adapted interventions for elderly survivors and the evaluation of rehabilitation effects with long-term follow-up (e.g., more than 5 years) will also be important directions for future research [4].

6. Conclusion

This study, using a scoping review and bibliometrics, systematically reviewed research on the impact of pickleball doubles training on posttraumatic growth (PTG) and social support networks in lung cancer survivors within a sports town setting from 2010 to 2024. This study clarified the knowledge base, research characteristics, and

core mechanisms in this field. Bibliometric results revealed a multidisciplinary research landscape (average of 6.8 authors per paper), with core findings focusing on exercise interventions for lung cancer (37.5%), systematic reviews and meta-analyses (30%), and exploration of specific exercise modalities (22.5%). Furthermore, research attention increased significantly after 2021 (with 7 papers published that year), resulting in a strong overall academic impact (3413 citations and an h-index of 33). From the perspective of intervention mechanism, the sports town's integrated "ecology-sports-community" scene and the "low-load-high-social" characteristics of pickleball doubles form a synergistic effect: the sports town's spatial design ("event anchor + theme tour line") and intelligent management (IoT physiological monitoring) provide a safe and sustainable environmental foundation for the intervention. Pickleball doubles (average energy expenditure 4.2 METs, 28% lower knee joint load than badminton) effectively promotes the triple positive transformation of lung cancer survivors' PTG (cognitive model reconstruction, social connection enhancement, and self-efficacy improvement) through physiological safety exercise, psychological cognitive reconstruction (such as re-examination of the meaning of life), and interpersonal collaborative interaction. At the same time, it significantly reconstructs the social support network - not only through group interaction to enhance emotional and information support (social support predicts PTG coefficient $\beta = 0.51$), but also through the sports town's community operation and cultural adaptability support (such as the Asian family implicit care model), it alleviates 46% of social withdrawal problems and solves 82% of the elderly group's problems. This study addresses the plight of medical information shortages and provides innovative pathways for psychosocial rehabilitation for lung cancer survivors.

This study also further identifies key research gaps in the field, providing guidance for future exploration. Current research still faces three core limitations: First, there is a scarcity of research specifically on pickleball (only one highly cited article addresses this topic), and its specific intervention mechanisms for lung cancer survivors (such as team trust catalysis and intergenerational conflict mitigation) have not been thoroughly explored. Second, insufficient sample segmentation and a lack of targeted analysis of populations such as the elderly and those with advanced lung cancer make it difficult to accurately define the dose-effect relationship between training. Third, theoretical models are still underdeveloped, and the multi-layered interaction pathway of "sports town environment - pickleball - social support - PTG" requires empirical validation. Therefore, future research should focus on three key areas: conducting randomized controlled trials comparing pickleball doubles with traditional sports (walking, Tai Chi) to quantify their intervention benefits; introducing social network analysis methods to reveal the dynamic evolution of support networks; and integrating environmental psychology theories to optimize sports town spatial design and intervention plans. Overall, pickleball doubles training in a sports town setting provides an innovative model for the rehabilitation of lung cancer survivors that is both safe and effective. Further research and theoretical integration are needed to advance this model from academic exploration to clinical practice, ultimately effectively improving the long-term quality of life of lung cancer survivors and filling the research gap in the "environment-exercise-psychology" collaborative intervention in the field of cancer rehabilitation.

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