



Research hotspots and trends in cancer rehabilitation: a bibliometric analysis (2013–2023)

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Abstract

Background Advances in medical care have made cancer rehabilitation an essential component of comprehensive cancer treatment. However, bibliometric analyses in this field remain limited. This study maps the global research landscape of cancer rehabilitation over the past decade.

Methods Relevant publications on cancer rehabilitation from 2013 to 2023 were retrieved from the Web of Science Core Collection (WoSCC) database. Bibliometric analysis was conducted using VOSviewer, CiteSpace, and the R package “Bibliometrics.”

Results A total of 6743 publications from 98 countries demonstrated sustained growth, peaking in 2022. The USA (1581 publications) and China (974) led in research output, while the Netherlands recorded the highest citation impact (32.75 citations per paper). Key institutions included the University of Texas MD Anderson Cancer Center (148 publications) and Memorial Sloan Kettering Cancer Center (40.58 citations per paper). *Supportive Care in Cancer* ranked as the most influential journal. Research efforts primarily focused on exercise interventions ($n = 404$), quality of life ($n = 688$), and breast cancer rehabilitation ($n = 440$). Recent trends highlighted telemedicine, digital health, and breast cancer-related lymphedema.

Conclusion This analysis highlights the dominance of high-income countries in cancer rehabilitation research and identifies exercise, quality of life, and breast cancer as enduring focal points. Emerging priorities include technology-driven interventions and lymphedema management. However, critical gaps remain, such as the underrepresentation of low-resource regions, limited focus on pediatric populations, and insufficient integration of advanced technologies (e.g., AI, wearables). Future efforts should emphasize equitable resource distribution, evidence-based pediatric rehabilitation models, and scalable technology-driven solutions to address global disparities and improve survivorship care.

Keywords Bibliometrics · Cancer rehabilitation · Research activity · Hotspots · Trends

Introduction

According to global cancer data from 2022, cancer has become a significant social, public health, and economic challenge in the twenty-first century. The data indicate that

nearly 20 million new cancer cases were reported in 2022, and approximately one in five men or women will develop cancer during their lifetime [1]. With advancements in medical technology, more cancers are being diagnosed and treated at earlier stages, resulting in a growing population of

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cancer survivors [2]. These survivors face a range of functional, cognitive, psychological, and economic challenges due to cancer and its treatment [3]. However, compared to the rehabilitation efforts for functional impairments caused by other diseases, the development of cancer rehabilitation remains insufficient. Most clinicians focus on prolonging disease-free survival and remission rates, often overlooking the importance of functional recovery [4].

In recent years, there has been an increasing call to integrate rehabilitation into cancer treatment [4–6]. “Cancer rehabilitation” is still an evolving concept. In 1978, Cromes stated that “Cancer rehabilitation aims to enable patients to achieve the best physical, social, psychological, and vocational functioning within the limits imposed by the disease and its treatment” [7]. Later, in 1981, Dr. J. Herbert Dietz, redefined cancer rehabilitation in the first cancer rehabilitation textbook, outlining four distinct phases: prevention, restoration, support, and palliative care [8]. In 2015, Julie K. Silver et al. proposed a new definition of cancer rehabilitation, incorporating key concepts from the International Classification of Functioning (ICF), such as changes in body structure/function, activity limitations, and participation restrictions. They defined cancer rehabilitation as a form of healthcare that should span the entire course of cancer care and be provided by trained rehabilitation professionals. These professionals are responsible for diagnosing and treating the physical, psychological, and cognitive impairments of patients to maintain or restore function, reduce the burden of symptoms, maximize independence, and improve the quality of life for this medically complex population [9].

With the growing focus on cancer rehabilitation, research in this field is steadily increasing. Bibliometrics, an important interdisciplinary field, analyzes the distribution structure, quantitative relationships, and patterns of change in literature using mathematical and statistical methods [10, 11]. Summarizing and synthesizing the characteristics of literature in this way help us understand development trends, research hotspots, and disciplinary

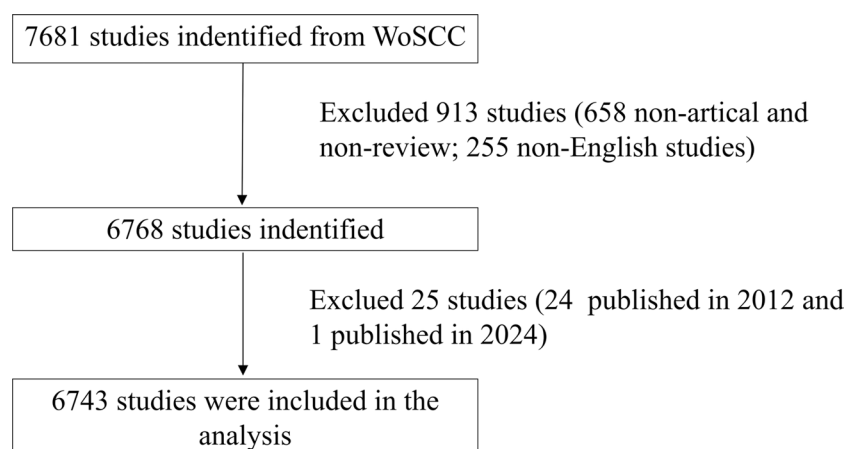
relationships in the field, which is crucial for advancing scientific research, optimizing information resource management, and facilitating academic exchanges [10, 11]. Although two studies have previously reviewed literature in the cancer rehabilitation field, covering the periods 1967–2008 [12] and 1992–2016 [13], the rapid development of this field in recent years necessitates an updated review to address three critical gaps: (1) mapping the current knowledge structure and collaborative networks in cancer rehabilitation research, (2) identifying leading contributors, including countries, institutions, and journals, along with emerging thematic trends, and (3) highlighting understudied populations or intervention types requiring further attention. To meet these objectives, we conducted a comprehensive bibliometric analysis of publications indexed in the Web of Science Core Collection (WoSCC) from 2013 to 2023. This study provides a systematic visualization of research landscapes, the temporal evolution of keywords, and potential directions for advancing cancer rehabilitation science.

Methods

Search strategy

We retrieved literature related to cancer rehabilitation from the WoSCC database (<https://www.webofscience.com/wos/woscc/basic-search>) for the period from January 1, 2013, to December 31, 2023. The search formula used was (((((TS = (Tumor*)) OR TS = (Neoplasia)) OR TS = (Neoplasm*)) OR TS = (Cancer*)) OR TS = (Malignant Neoplasm*)) OR TS = (Malignanc*)) AND ((TS = (Rehabilitation)) OR TS = (Habilitation))), with the language restricted to English and the document types limited to articles and review articles. The specific search process is illustrated in Fig. 1.

Fig. 1 Flowchart of literature search



Data analysis

VOSviewer (1.6.20), CiteSpace (6.3.R1), the “bibliometrix” package of R (version 4.3.3), and Microsoft Office Excel (2019) were used for analysis and visualization. Specifically, Excel was employed for data statistics and visualization of the literature. VOSviewer [14, 15] was utilized for country and institution analysis, journal and co-cited journal analysis, author and co-cited author analysis, and keyword co-occurrence analysis. CiteSpace, developed by Professor Chaomei Chen’s team, is widely used in bibliometric analysis [15, 16]. In this study, we used CiteSpace for dual-map overlay of journals and citation burst analysis. Geographical distribution and trend topic analysis were conducted using the “bibliometrix” package of R (<https://www.bibliometrix.org>). Journal quartiles and impact factors were referenced from the Journal Citation Reports 2024.

Results

Quantitative analysis of publication

A total of 6743 studies related to cancer rehabilitation were identified for the period from 2013 to 2023, comprising 5430 articles and 1313 review articles. The number of publications in this field has shown a steady year-on-year increase, peaking in 2022 with 896 publications. However, there was a slight decline in the number of publications in 2023 (Fig. 2).

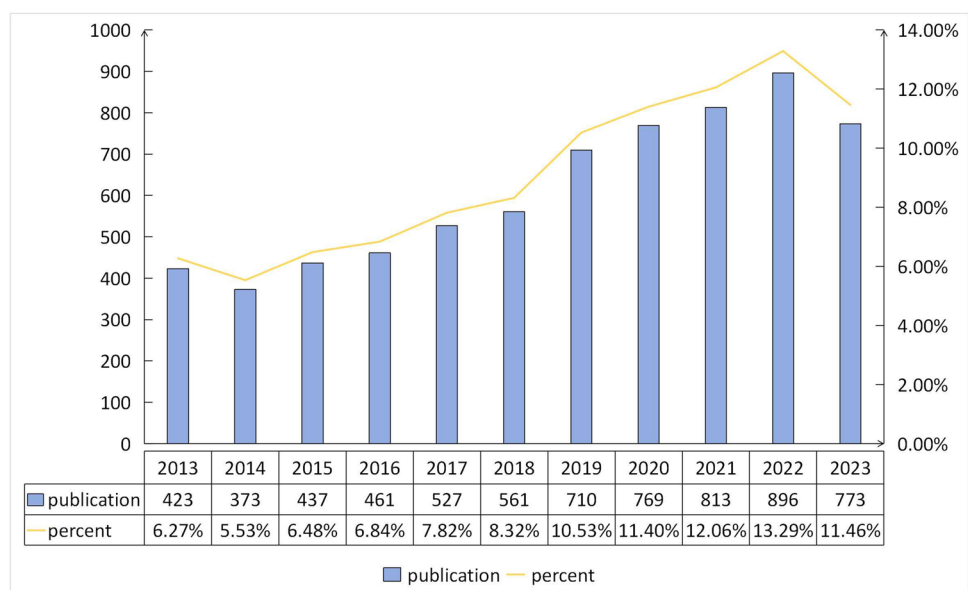
Country and institutional analysis

The 6743 publications originated from 98 countries and 7752 institutions. The top 10 contributing countries are primarily located in Europe ($n=5$), North America ($n=2$), Asia ($n=2$), and Oceania ($n=1$) (Table 1). The USA and China lead in the number of publications, with 1581 and 974 publications, respectively. The USA also recorded the highest total citations, with 34,975 citations and an average of 22.12 citations per paper. In contrast, China had the lowest average citation frequency, with 11,043 citations for 974 publications, averaging only 11.34 citations per paper. The Netherlands achieved the highest average citation frequency, with 359 publications receiving 11,756 citations, resulting in an average of 32.75 citations per paper. Visualization

Table 1 Top 10 countries of cancer rehabilitation

Rank	Country	Publication	Citations	Average citation/publication
1	The USA (North America)	1581	34,975	22.12
2	China (Asia)	974	11,043	11.34
3	UK (Europe)	613	17,631	28.76
4	Italy (Europe)	492	10,937	22.23
5	Canada (North America)	474	12,945	27.31
6	Germany (Europe)	470	11,456	24.37
7	Australia (Oceania)	453	9457	20.88
8	Netherlands (Europe)	359	11,756	32.75
9	Denmark (Europe)	317	7377	23.27
10	Japan (Asia)	304	3782	12.44

Fig. 2 The annual publication volume of cancer rehabilitation. The yellow line is the percentage of the number of published papers in the year to the total number of papers from 2003 to 2023



was conducted for 47 countries using a filter criterion of a minimum of ten publications per country (Fig. 3), revealing strong collaboration among these countries.

The top 10 institutions (Table 2) are predominantly based in the USA ($n=4$), Canada ($n=2$), Denmark ($n=2$), the Netherlands ($n=1$), and Australia ($n=1$). The University of Texas MD Anderson Cancer Center had the highest number of publications, with 148, followed by

The University of Toronto with 138 publications. These institutions received 3639 and 4303 citations, respectively, with average citation frequencies of 24.59 and 31.18 per paper. Memorial Sloan Kettering Cancer Center ranked first in average citation frequency, with 40.58 citations per paper from its 84 publications. Visualization was performed for 42 institutions with at least 40 publications (Fig. 4), showing significant collaboration among these leading institutions.

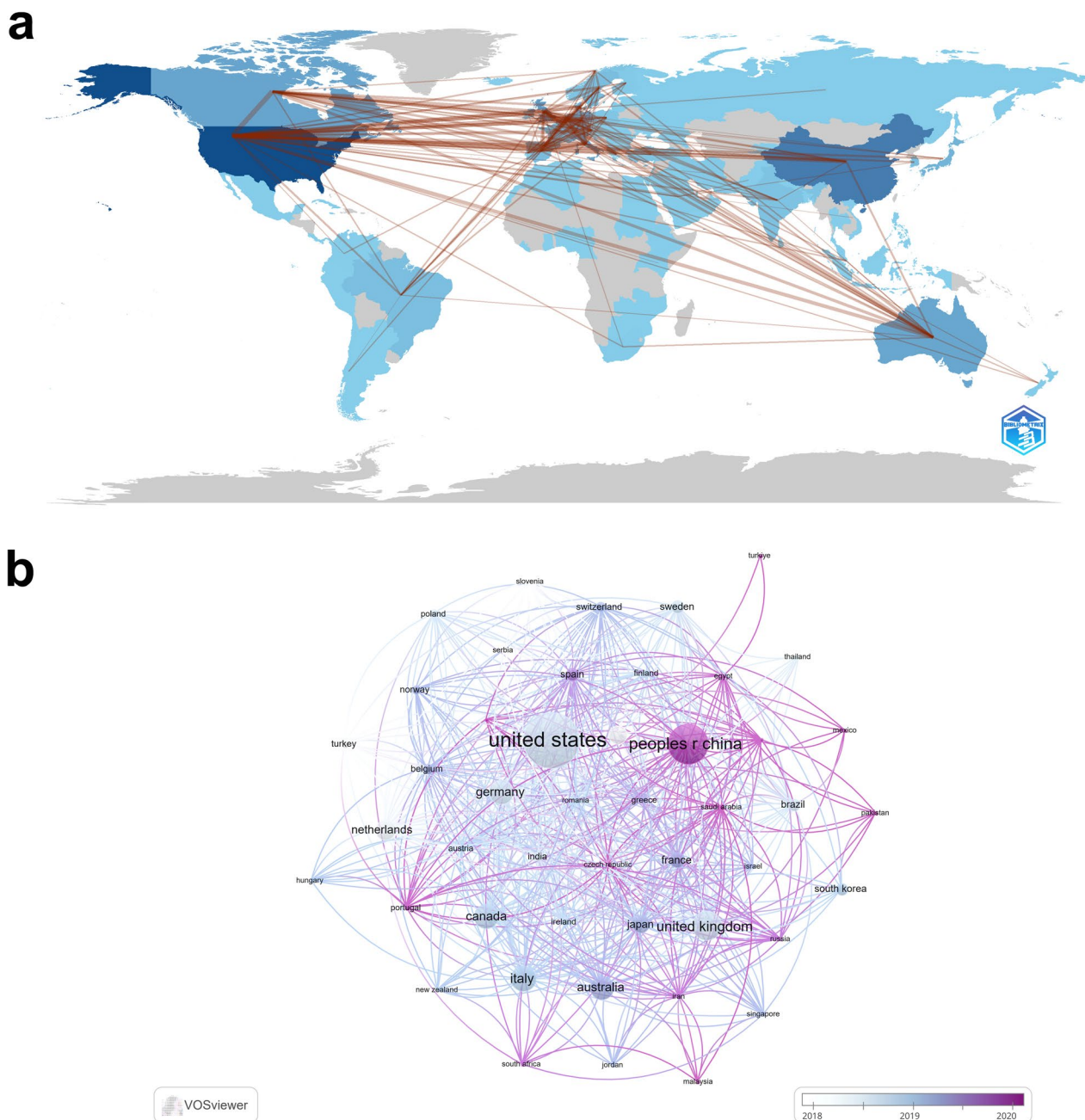


Fig. 3 Visualization results of geographical distribution (a) and countries (b) of cancer rehabilitation research

Rank	Organization	Publication	Citations	Average citation/publication
1	The University of Texas MD Anderson Cancer Center (The USA)	148	3639	24.59
2	The University of Toronto (Canada)	138	4303	31.18
3	University of Copenhagen (Denmark)	121	2182	18.03
4	University of Southern Denmark (Denmark)	94	1222	13.00
5	Mayo Clinic (The USA)	92	2620	28.48
6	Harvard Medical School (The USA)	90	1809	20.10
7	Memorial Sloan Kettering Cancer Center (The USA)	84	3409	40.58
8	University of Amsterdam (Netherlands)	84	2590	30.83
9	University of Alberta (Canada)	80	1565	19.56
10	The University of Queensland (Australia)	80	1727	21.59



Journals and co-cited journals

highest number of publications, with 308 articles receiving 4738 citations, resulting in an average citation frequency of 15.38. *BMJ Open* followed with 119 publications and 1303 citations, averaging 10.95 citations per paper. The journal

Table 3 Top 10 journals and co-cited journals of cancer rehabilitation research

Rank	Journal	Publication	Citation	Average citation/ publication	IF	Q	Co-cited journal	Co-citation	IF	Q
1	Supportive Care in Cancer	308	4738	15.38	2.8	Q1	Journal of Clinical Oncology	6120	42.1	Q1
2	BMJ Open	119	1303	10.95	2.4	Q1	Supportive Care in Cancer	5697	2.8	Q1
3	Archives of Physical Medicine and Rehabilitation	117	3221	27.53	3.6	Q1	Cancer	3576	6.1	Q1
4	Disability and Rehabilitation	103	1424	13.83	2.1	Q1	Psycho-Oncology	3536	3.3	Q1
5	Journal of Cancer Survivorship	98	1845	18.83	3.1	Q1	Archives of Physical Medicine and Rehabilitation	2659	3.6	Q1
6	European Journal of Cancer Care	92	1438	15.63	1.8	Q2	Cochrane Database of Systematic Reviews	2543	8.8	Q1
7	BMC Cancer	81	1531	18.90	3.4	Q2	Head and Neck-Journal for the Sciences and Specialties of the Head and Neck	2528	2.3	Q2
8	Acta Oncologica	80	2061	25.76	2.7	Q3	Journal of Cancer Survivorship	1914	3.1	Q1
9	Psycho-oncology	79	1934	24.48	3.3	Q1	Plos One	1911	2.9	Q1
10	Cancers	77	638	8.29	4.5	Q1	Acta Oncologica	1899	2.7	Q3

predominantly cite literature from the molecular/biology/genetics, health/nursing/medicine, and economics/economic/political fields. The gray path shows that research in neurology/sports/ophthalmology frequently cites literature from the health/nursing/medicine field.

Authors and co-cited authors

A total of 32,836 authors contributed to cancer rehabilitation research. Among the top 10 authors by publication count, Jack B. Fu and Eduardo Bruera each have over 30 publications (Table 4). Specifically, Jack B. Fu has authored 37 publications, which have received 547 citations, resulting in an average citation frequency of 14.78. Eduardo Bruera's 36 publications received 467 citations, with an average citation frequency of 12.97. Notably, the author with the highest average citation frequency is Francesco Carli, whose 21 publications have been cited 2234 times, averaging 106.38 citations per publication. A collaboration network of 33 authors with a minimum of 15 publications was visualized (Fig. 7a), showing that Jack B. Fu and Eduardo Bruera occupy the largest nodes, indicating close collaboration. For instance, Jack B. Fu collaborates closely with seven other authors, including Eduardo Bruera, Julie K. Silver, Mackenzi Pergolotti, Catherine M. Alfano, Tetsuya Tsuji, Arash Asher, and Shinichiro Morishita.

In this field, 119,557 authors have been co-cited. Among the top 10 co-cited authors, five have been cited more than 400 times (Table 4). Lee W. Jones leads with 684 citations, followed by Kathryn H. Schmitz with 591 citations. Visualization was conducted for 32 co-cited authors with a minimum of 180 co-citations (Fig. 7b).

Co-cited references

From 2013 to 2023, 188,202 references in the field of cancer rehabilitation were co-cited. The top 10 co-cited references were cited at least 126 times (Table 5). The most frequently cited reference is "Aaronson NK, 1993, J Natl Cancer I, V85, P36," with 358 citations.

Reference with citation bursts

Citation burst references are those that experience a significant increase in citations within a specific period, indicating a surge of interest from scholars in a particular field [28]. In this study, 14 references with strong citation bursts were identified (Fig. 8). Each bar in the figure represents a year, with the red segments indicating periods of strong citation bursts [29]. The earliest citation burst occurred in 2015, while the most recent was in 2021. The reference with the strongest citation burst was published by Campbell KL et al. in *MED SCI SPORT EXER* in 2019, titled "Exercise

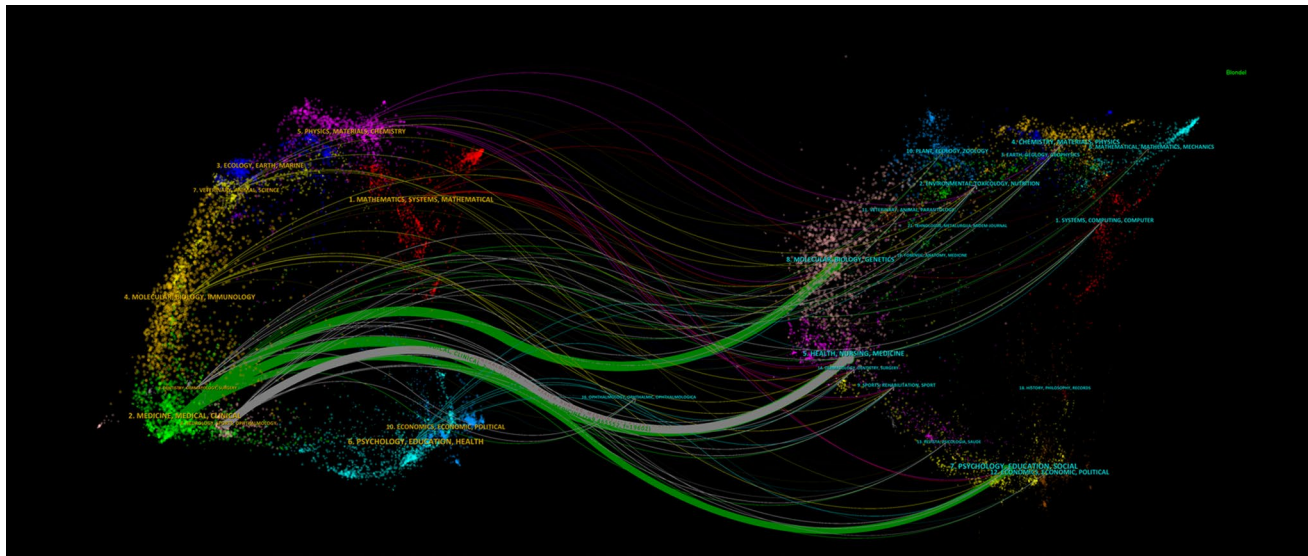


Fig. 6 The double-map overlay of journals on cancer rehabilitation research

Table 4 Top 10 authors and co-cited authors in cancer rehabilitation research

Rank	Authors	Publication	Citations	Average citation/ publication	Co-cited-authors	Citation
1	Jack B. Fu	37	547	14.78	Lee W Jones	684
2	Eduardo Bruera	36	467	12.97	Kathryn H Schmitz	591
3	Catherine L. Granger	28	624	22.29	Kerry S Courneya	538
4	Christoffer Johansen	27	811	30.04	Andrea L Cheville	465
5	Linda Denehy	26	562	21.62	Ahmedin Jemal	447
6	Julie K Silver	25	1349	53.96	Julie K Silver	399
7	Mackenzi Pergolotti	24	526	21.92	Neil K Aaronson	384
8	Francesco Carli	21	2234	106.38	Anne Mehnert	358
9	Alessandro de Sire	21	246	11.71	Nicole L Stout	334
10	Matthew Maddocks	21	677	32.24	World Health, Organization	310

Guidelines for Cancer Survivors: Consensus Statement from International Multidisciplinary Roundtable,” which maintained its citation intensity from 2021 to 2023. Following this was the literature by Schmitz KH et al., also published in *MED SCI SPORT EXER*, titled “American College of Sports Medicine Roundtable on Exercise Guidelines for Cancer Survivors,” which had a burst intensity of 24.6479 and lasted from 2013 to 2015. Overall, the burst intensities of the 14 references ranged from 12.384 to 35.9882, with durations of 2–3 years.

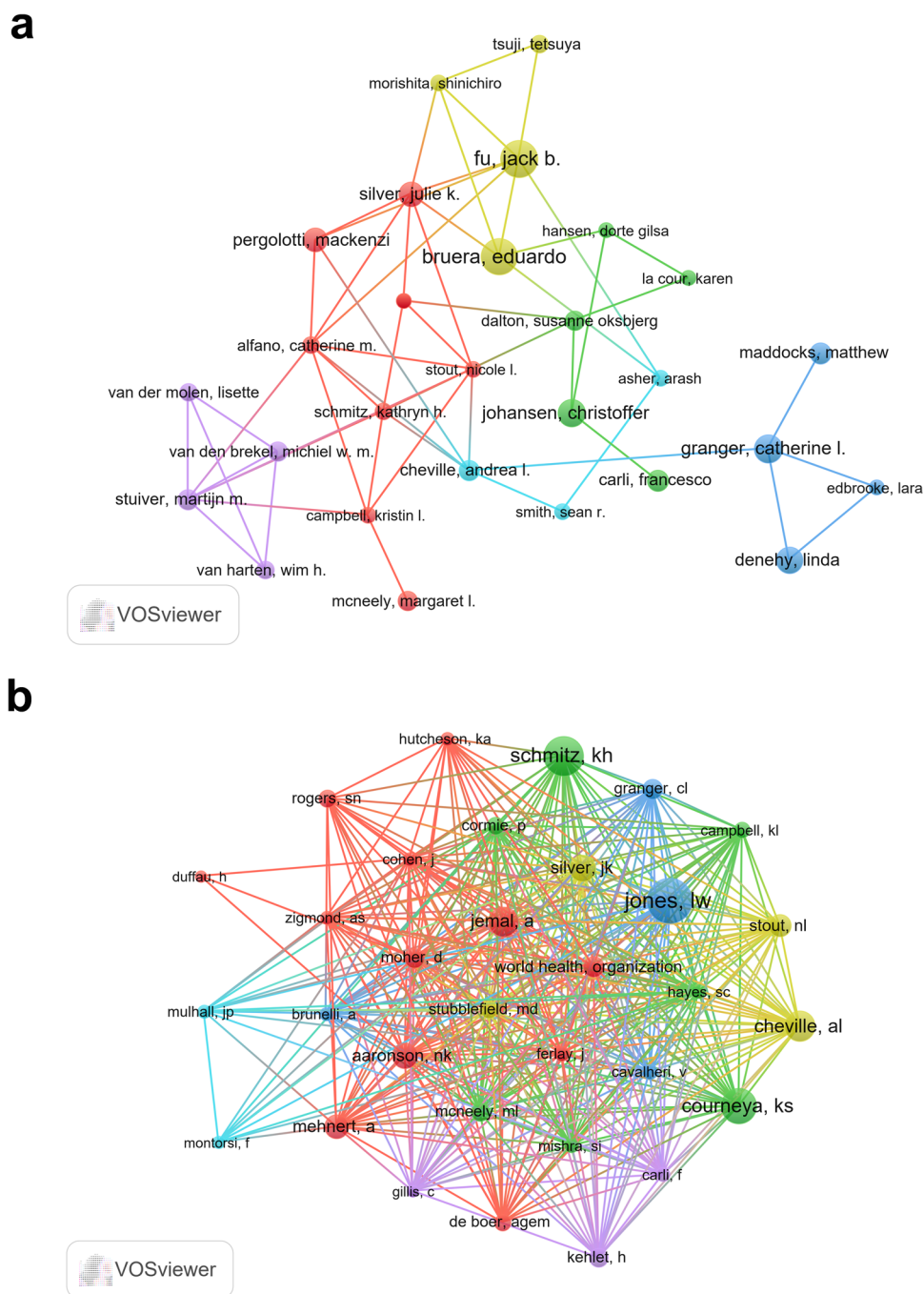
Hotspots and frontiers

By analyzing the co-occurrence of author keywords, the top 20 author keywords were identified (Table 6). These keywords appeared at least 100 times in the literature. Notably,

“quality of life” ($n=688$) and “return to work” ($n=100$) emerged as the primary objectives of tumor rehabilitation. The most frequently researched cancer types include breast cancer ($n=440$), head and neck cancer ($n=294$), lung cancer ($n=207$), and prostate cancer ($n=144$). Among the treatment stages, surgery ($n=149$) and radiotherapy ($n=123$) have been the focus of more extensive study. Symptoms such as fatigue ($n=107$) and dysphagia ($n=116$) have gained significant attention in the context of tumor rehabilitation. The main intervention methods highlighted were exercise ($n=404$) and physical activity ($n=238$). A network diagram was created by filtering author keywords with a frequency of no less than 70 occurrences (Fig. 9a).

The keyword trend analysis (Fig. 9b) reveals shifts in research focus over time. From 2013 to 2015, the emphasis in tumor rehabilitation research was on psychological

Fig. 7 The visualization of authors (a) and co-cited authors (b) in cancer rehabilitation research



support, sickness absence, and dysarthria. Between 2016 and 2018, the focus shifted toward osseointegration and voice prosthesis, with increasing attention to comorbidity and fatigue, particularly in relation to prostate cancer. From 2019 to 2021, research increasingly concentrated on head and neck cancers and breast cancer, with a growing emphasis on exercise and quality of life. In the past 2 years, as medical technology has advanced, cancer rehabilitation has begun to incorporate telemedicine, digital health, and implementation science. Additionally, breast

cancer lymphedema has gained attention, indicating a potential direction for future research.

Discussion

General information

The field of tumor rehabilitation has received increasing attention, as evidenced by the growing number of published

Table 5 Top 10 co-cited references in cancer rehabilitation research

Rank	Co-cited reference	Citations
1	Aaronson NK, 1993, J Natl Cancer I, V85, P365 [18]	358
2	Schmitz KH, 2010, Med Sci Sport Exer, V42, P1409 [19]	300
3	Jemal A, 2011, Ca-Cancer J Clin, V61, P134 [20]	234
4	Moher D, 2010, Int J Surg, V8, P336 [21]	230
5	Zigmond AS, 1983, Acta Psychiat Scand, V67, P361 [22]	206
6	Campbell KL, 2019, Med Sci Sport Exer, V51, P2375 [23]	167
7	Crapo RO, 2002, Am J Resp Crit Care, V166, P111 [24]	161
8	Jemal A, 2009, Ca-Cancer J Clin, V59, P225 [25]	148
9	Cohen J., 1988, Statistical Power Analysis for the Behavioral Sciences [26]	144
10	Dindo D, 2004, Ann Surg, V240, P205 [27]	126

Top 14 References with the Strongest Citation Bursts

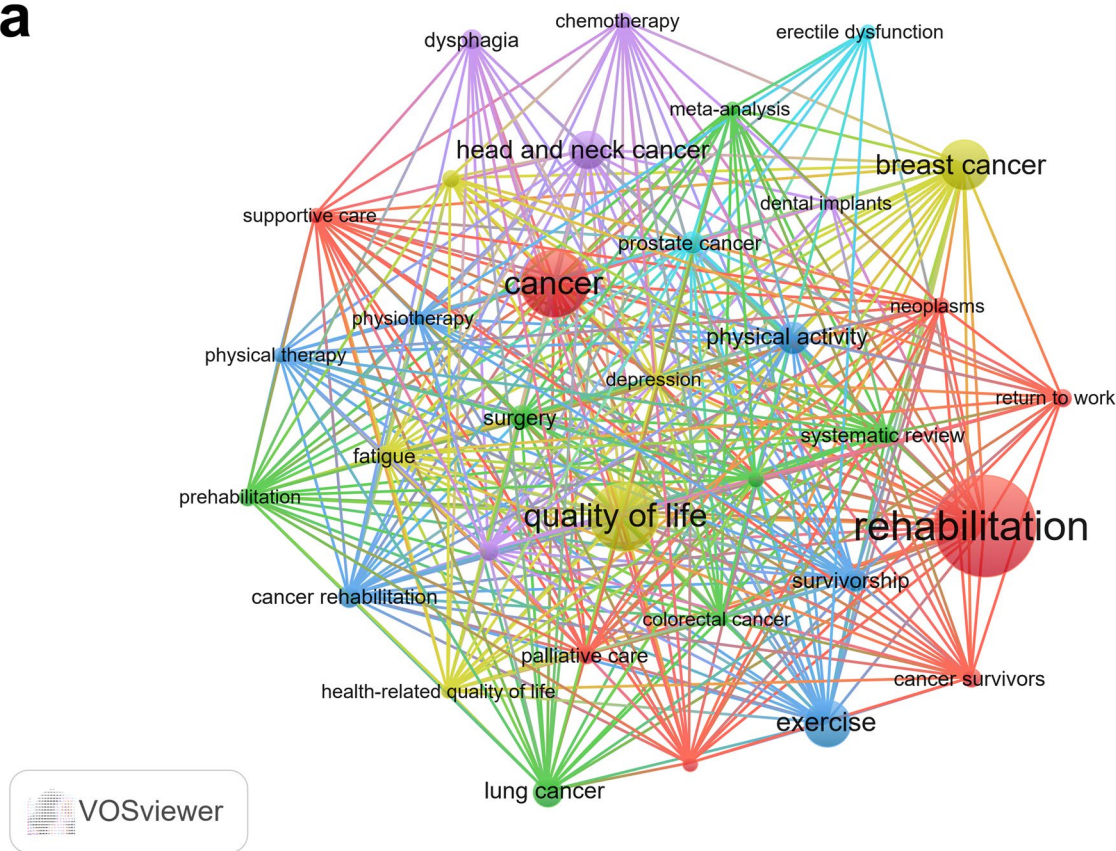
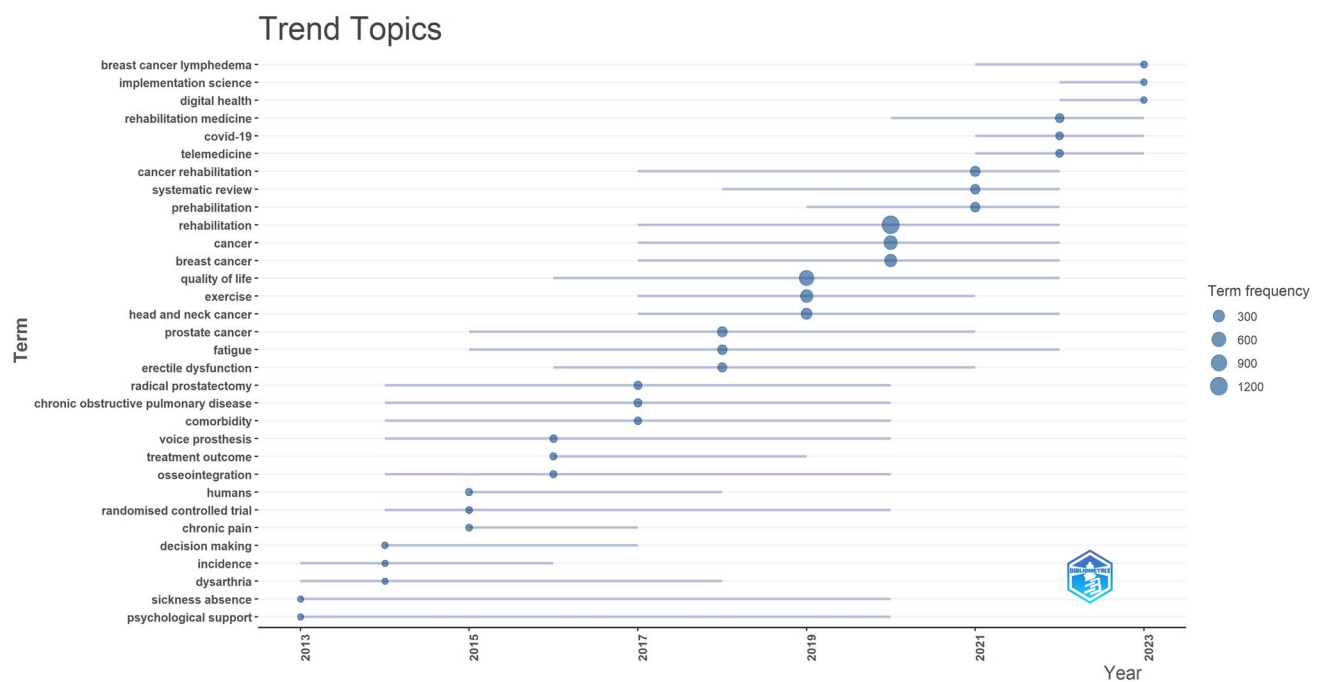
References	Year	Strength	Begin	End	2013 - 2023
Schmitz KH, 2010, MED SCI SPORT EXER, V42, P1409, DOI 10.1249/MSS.0b013e3181e0c112, DOI	2010	27.65	2013	2015	
Speck RM, 2010, J CANCER SURVIV, V4, P87, DOI 10.1007/s11764-009-0110-5, DOI	2010	18.38	2013	2015	
Mehnert A, 2011, CRIT REV ONCOL HEMAT, V77, P109, DOI 10.1016/j.critrevonc.2010.01.004, DOI	2011	15.39	2013	2016	
Granger CL, 2011, LUNG CANCER, V72, P139, DOI 10.1016/j.lungcan.2011.01.006, DOI	2011	13.67	2013	2016	
Arbane G, 2011, LUNG CANCER, V71, P229, DOI 10.1016/j.lungcan.2010.04.025, DOI	2011	12.38	2013	2016	
Mishra SI, 2012, COCHRANE DB SYST REV, V0, P0, DOI 10.1002/14651858.CD008465.pub2, DOI	2012	18.34	2015	2017	
Silver JK, 2013, CA-CANCER J CLIN, V63, P295, DOI 10.3322/caac.21186, DOI	2013	15.05	2015	2018	
Gillis C, 2014, ANESTHESIOLOGY, V121, P937, DOI 10.1097/ALN.0000000000000393, DOI	2014	14.38	2016	2019	
Ferlay J, 2015, INT J CANCER, V136, PE359, DOI 10.1002/ijc.29210, DOI	2015	15.73	2017	2020	
Stout NL, 2016, ARCH PHYS MED REHAB, V97, P2006, DOI 10.1016/j.apmr.2016.05.002, DOI	2016	14.28	2017	2020	
Silver JK, 2015, SUPPORT CARE CANCER, V23, P3633, DOI 10.1007/s00520-015-2916-1, DOI	2015	13.32	2017	2020	
Schmitz KH, 2019, CA-CANCER J CLIN, V69, P468, DOI 10.3322/caac.21579, DOI	2019	14.08	2020	2023	
Cavalheri V, 2017, COCHRANE DB SYST REV, V0, P0, DOI 10.1002/14651858.CD012020.pub2, DOI	2017	13.91	2020	2023	
Campbell KL, 2019, MED SCI SPORT EXER, V51, P2375, DOI 10.1249/MSS.0000000000002116, DOI	2019	35.99	2021	2023	

Fig. 8 Top 14 references with the strongest citation bursts. A red bar indicates high citations in that year [4, 9, 19, 23, 30–39]**Table 6** Top 20 author keywords for cancer rehabilitation research

Rank	Keywords	Counts	Rk	Keywords	Counts
1	Rehabilitation	1210	11	Prostate cancer	144
2	Quality of life	688	12	Cancer rehabilita- tion	139
3	Cancer	671	13	Radiotherapy	123
4	Breast cancer	440	14	Dysphagia	116
5	Exercise	404	15	Systematic review	113
6	Head and neck cancer	294	16	Fatigue	107
7	Physical activity	238	17	Cancer survivors	105
8	Lung cancer	207	18	Palliative care	104
9	Survivorship	154	19	Return to work	100
10	Surgery	149	20	Lymphedema	99

papers. Over the 10-year period from 2013 to 2023, 6743 papers were retrieved from the WoSSC database—approximately seven times the number of papers published between 1967 and 2008 [12]. The data shows a consistent upward trend in publication numbers, with more than 710 papers published annually since 2019. This indicates that tumor rehabilitation has become a significant focus of research in recent years.

From a global perspective, while European countries contribute a substantial amount of literature in this field, the USA (North America) and China (Asia) lead in the number of publications. The USA ($n = 1581$) and China ($n = 978$) occupy the top two positions in terms of publication volume. Interestingly, the countries with the highest average citations per paper are predominantly European. Despite their high publication numbers, the USA and China have relatively low average citation rates of 22.12 and 11.34 per paper, respectively, ranking near the bottom. This suggests that while these countries are prolific in producing research,

a**b****Fig. 9** Author keywords co-occurrence analysis (a) and trend topics analysis (b)

there is room for improvement in the quality and impact of their publications.

The top 10 institutions contributing to this field are spread across five countries, with two-fifths located in the USA. The findings also indicate that the institutions with the highest number of publications and the highest average citations per paper are based in the USA. This highlights the significant investment and focus that US institutions place on research in cancer rehabilitation. Notably, research productivity and impact in this field remain concentrated in high-income countries, such as the USA, the Netherlands, and Germany, likely due to well-developed healthcare systems and dedicated research funding.

Research on tumor rehabilitation is predominantly published in the journal *Supportive Care in Cancer*, highlighting its prominence in this field. The journal's impact factor and quartile rankings reflect its quality, influence, and reach. While the impact factor is relatively modest, most of the journals in this field fall within Q1 and Q2 quartiles. This suggests that while tumor rehabilitation is gaining recognition, further research efforts are necessary, along with greater support from higher-impact international journals, to improve the field's visibility and influence.

The top 10 authors in tumor rehabilitation have each published over 20 papers, with Jack B. Fu leading in publication volume. He has advocated that the future of cancer rehabilitation will be shaped by the concept of “exercise as cancer medicine,” suggesting that this approach could significantly advance the field [40]. Between 2013 and 2023, Jack B. Fu closely collaborated with Eduardo Bruera, resulting in 27 joint publications. Eduardo Bruera is a well-regarded expert in cancer palliative care. Their collaborative work primarily addresses topics such as symptoms [41, 42], patient expectations [43], movement disorders, and patient adherence [44] in cancer care.

Among the co-cited authors, Lee W. Jones stands out with 684 citations. His research primarily focuses on breast cancer, particularly the quality of life following chemotherapy [45] and the optimal timing for exercise intervention during adjuvant chemotherapy [46]. Kathryn H. Schmitz, with 591 citations, is another highly influential author in this field. Her research centers on exercise interventions, with a strong emphasis on lymphedema rehabilitation in breast cancer patients. Schmitz conducted a cohort study on breast cancer patients with arm edema from 1990 to 2010, demonstrating that early intervention can significantly reduce medical costs [47]. From 2012 to 2016, she led a 52-week exercise intervention involving 351 breast cancer lymphedema patients, highlighting the critical role of supervised exercise programs [48]. In 2019, Schmitz was the first to propose the concept of “exercise as medicine” in oncology, urging clinicians to actively incorporate physical activity into cancer care [38]. She further reinforced this concept in a January 2023

commentary in the *Journal of Clinical Oncology*, advocating for the integration of exercise as a standard component of medical oncology [49]. These studies highlight the significant attention breast cancer lymphedema has received, indicating a solid research foundation in this area. However, there remains a need for more in-depth research. The importance of exercise in tumor rehabilitation is widely recognized, and future efforts should focus on developing more precise and tailored exercise intervention programs.

Knowledge base

Co-cited references often represent the foundational research within a specific field [50]. In this study, the most frequently cited reference is the development of the European Organisation for Research and Treatment of Cancer (EORTC) QLQ-C30 questionnaire, which was published by Aaronson et al. in 1993 [18]. This highlights the widespread use of the EORTC QLQ-C30 in cancer rehabilitation research and highlights the importance of quality of life as a key measure of rehabilitation outcomes. Additionally, the high citation count for the development of the Hospital Anxiety and Depression Scale [22] reflects the significance of anxiety and depression as critical factors in evaluating the efficacy of tumor rehabilitation. The second most-cited reference is the *American College of Sports Medicine roundtable on exercise guidelines for cancer survivors*, published by Schmitz et al. in 2010. This paper emphasizes that exercise training during and after adjuvant cancer therapy is safe and can improve physical function, quality of life, and reduce fatigue in patients [19]. In 2018, Kristin L. Campbell et al. convened a second roundtable, concluding that specific doses of aerobic, combined aerobic and resistance training, or resistance training alone can significantly improve various cancer-related health outcomes, including anxiety, depression, fatigue, physical functioning, and health-related quality of life [23]. These studies have solidified the role of exercise in cancer rehabilitation, establishing exercise intervention as a core component of the field.

Hotspots and frontiers

A citation explosion indicates that certain references are frequently cited within a specific period, often reflecting emerging topics in a field [28]. Our research reveals that the primary research hotspots in cancer rehabilitation continue to focus on exercise and quality of life. The co-occurrence of author keywords further highlights that quality of life remains a central concern in tumor rehabilitation. The emphasis on quality of life reflects broader improvements in living standards and medical care, making it a key indicator for assessing the well-being of cancer patients [34]. Another emerging but significant keyword is “return to

work.” Employment plays a critical role in self-efficacy and identity, significantly impacting health, well-being, and quality of life [51]. However, cancer often forces many individuals to leave the workforce due to treatment and its side effects, leading to serious personal and economic consequences [52]. Studies indicate that cancer survivors face a substantially increased risk of unemployment and early retirement, with lower chances of re-employment. Between 26 and 53% of cancer survivors lost their jobs or stopped working within 72 months after diagnosis, and 23 to 75% of those who became unemployed were re-employed. Compared to non-cancer populations, a significant portion of cancer survivors experienced changes in work hours, wages, and overall working capacity [31]. For cancer survivors, returning to work not only helps restore the economic stability disrupted by diagnosis and treatment but also reinstates social interactions and status [53]. This is crucial for improving their quality of life. As the number of cancer patients and survivors continues to rise, “return to work” may emerge as a key research focus in the future.

Based on our research findings, breast cancer receives the most attention among cancer types. Breast cancer is the most common malignancy in women, with nearly eight million women worldwide surviving at least 5 years after diagnosis, representing about 40% of all cancer survivors [54]. During treatment, breast cancer patients face not only changes in body image and long-term lymphedema but also physical discomforts such as anxiety, depression, insomnia, and hot flashes, often resulting from hormonal changes induced by endocrine therapy [55]. This highlights the critical importance of rehabilitation for breast cancer patients. Currently, numerous studies are focused on addressing issues such as lymphedema [56, 57], emotional changes [58, 59], hormone-induced sexual dysfunction [55], and the recovery of work ability [60] in breast cancer patients. Trend analysis indicates that breast cancer lymphedema has emerged as a significant research hotspot in recent years. Additionally, other areas of focus include dysphagia related to radiotherapy for head and neck cancer and complications experienced by lung cancer patients following surgery. The “Speech and Swallow Rehabilitation in Head and Neck Cancer: United Kingdom National Multidisciplinary Guidelines,” published in 2016, recommends preventive swallowing exercises to reduce damage, maintain function, and accelerate recovery. The guidelines emphasize that continuous speech stimulation is crucial for preserving pronunciation and ensuring safe, effective swallowing following head and neck cancer treatment [61]. Similarly, studies have shown that preoperative exercise can reduce the risk of postoperative pulmonary complications in patients with non-small cell lung cancer [39]. These findings highlight the vital role of exercise in cancer rehabilitation.

Consistent with the citation burst results, keyword analysis also highlights the key role of exercise in tumor rehabilitation. The 2010 American College of Sports Medicine Roundtable was the first to conclude that cancer survivors, including those with breast and prostate cancer, can safely engage in sufficient exercise training to improve physical health, restore function, enhance quality of life, and alleviate cancer-related fatigue [19]. In 2016, American institutions, led by the National Institutes of Health, advocated for integrating rehabilitation care models into oncology, calling for a national focus on oncology rehabilitation [4]. As research in this area has grown, the American College of Sports Medicine held another roundtable in 2018, confirming that specific doses of aerobic, combined aerobic and resistance training, and/or resistance training can significantly improve health outcomes related to cancer, such as anxiety, depressive symptoms, fatigue, physical function, and health-related quality of life [23]. Furthermore, in 2021, Kathryn H. Schmitz and colleagues, building on previous findings, emphasized the need for physicians to actively participate in the rehabilitation of cancer patients and introduced the concept of “exercise as medicine” in oncology [38]. These developments highlight the crucial importance of exercise in cancer rehabilitation.

Limitations

Although we used three widely recognized bibliometric analysis tools to study cancer rehabilitation research in the WoSCC database over the past 10 years, and the results obtained are relatively objective and comprehensive, some limitations must be acknowledged. This study relied on a single source and language, which may have led to incomplete literature retrieval. Large-scale retrieval across multiple databases and languages remains challenging and is a common limitation in bibliometric analyses [62].

Conclusions

This decade-long bibliometric analysis highlights significant progress in cancer rehabilitation research while revealing critical gaps that require further investigation. High-income countries, such as the USA and the Netherlands, continue to lead in research output and impact, whereas low- and middle-income regions remain underrepresented despite facing a disproportionate cancer burden. Addressing this imbalance will require future studies to focus on resource-limited settings, utilizing telemedicine and mobile health technologies to expand access to evidence-based rehabilitation protocols. The sustained emphasis on exercise interventions and quality of life reflects their central role

in survivorship care. However, emerging challenges, such as breast cancer-related lymphedema, call for innovative, multidisciplinary approaches. The integration of artificial intelligence for personalized rehabilitation planning and wearable devices for real-time functional monitoring has the potential to transform patient-centered care. Additionally, pediatric cancer rehabilitation remains significantly understudied—an important gap considering the unique developmental needs of young survivors. To guide future research, three key directions are proposed: (1) equity-driven innovation: develop scalable, low-cost interventions tailored to underserved populations, particularly in Africa and South Asia; (2) technology integration: establish frameworks for implementing AI-driven tools, such as predictive analytics for lymphedema risk, and digital platforms for remote patient engagement; and (3) cross-disciplinary collaboration: strengthen partnerships among oncologists, rehabilitation scientists, policymakers, and patients to co-design interventions that address both the physical and psychosocial effects of cancer. By prioritizing these areas, the field can overcome existing limitations, ensuring that advancements in cancer rehabilitation are equitably distributed across diverse global contexts.

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Data availability No datasets were generated or analysed during the current study.

Declarations

Conflict of interest The authors declare no competing interests.

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