

Review

Exercise as a psychosocial intervention in cancer care: A bibliometric and systematic review of mechanisms and outcomes

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Abstract: Cancer patients often experience anxiety and depression during the progression of their disease. Traditional psychological interventions face limitations due to drug side effects and uneven resource allocation. Exercise therapy has become an important rehabilitation strategy through multi-pathway mechanisms, but the heterogeneity of exercise therapy and its mechanisms remains understudied. This study combined bibliometrics and systematic reviews to retrieve literature on exercise intervention and psychosocial rehabilitation of cancer in the Web of Science (WOS) Core Collection (2000–2023). Bibliometric methods were used to analyze the exercise-psychology-biomarker network quantitatively, and a total of 51 high-quality studies that met the PRISMA guidelines were included. Bibliometric analysis showed that the research showed an exponential growth trend, with the United States, Germany, and China as the core research areas; high-frequency cited literature confirmed that aerobic combined resistance training has a significant effect on alleviating psychological distress and improving quality of life. The systematic review further showed that exercise achieves psychological rehabilitation through the triple pathways regulating hypothalamic-pituitary-adrenal (HPA) axis function, reducing proinflammatory factors, and enhancing neuroplasticity. This study provides a multi-dimensional evidence chain for the clinical transformation of exercise therapy, and it is recommended that future research focus on gene-environment interactions and the long-term effects of remote exercise intervention models.

Keywords: exercise mode; cancer patients; psychological rehabilitation; neurobiological mechanism; psychosocial pathway; bibliometric analysis; precision rehabilitation strategies; aerobic exercise; resistance training; mind-body exercise

1. Introduction

Epidemiological studies have shown that approximately 40%–50% of cancer patients experience significant anxiety or depression symptoms during diagnosis and treatment [1,2]. The root cause is not only the threat to survival posed by the disease itself, but is also closely related to cognitive impairment, loss of physical function, and lack of social support caused by chemotherapy. Traditional psychological interventions face a double dilemma: the physiological cost of drug treatment (such as Selective Serotonin Reuptake Inhibitor (SSRIs)), which may increase the risk of recurrence and reduce survival) and the serious imbalance of social and psychological resources (the coverage rate of psychological counseling in low-income areas is less than 20%), which limits the actual efficacy [3,4].

Recent research has put forward a groundbreaking hypothesis regarding the psychophysiological regulation of exercise intervention in cancer patients. Regular physical activity is posited to enhance neuroplasticity by increasing the secretion of brain-derived neurotrophic factor (BDNF). This enhancement serves as a countermeasure against chemotherapy-induced cognitive decline, as reported in

studies [5,6]. Meanwhile, exercise exerts a regulatory effect on the hypothalamic-pituitary-adrenal (HPA) axis. Studies have shown that it reduces cortisol levels by more than 31.2% from baseline values, thereby alleviating chronic stress-related anxiety [7,8]. It is worth noting that different exercise modalities pose an impact on psychological rehabilitation through distinct underlying mechanisms. In accordance with the guidelines set by the American College of Sports Medicine (ACSM) [9], aerobic exercise has been demonstrated to increase prefrontal blood-oxygen-level-dependent (BOLD) signals and the concentration of plasma β -endorphin. The release of β -endorphin, as described by Boecker et al. [10], and the enhancement of prefrontal neuroplasticity, as reported by Voss et al. [11], act in synergy to alleviate depression, as noted by Schuch et al. [5].

Resistance exercise differentially regulates psychological stress and cognitive function in cancer patients, by the mean of inhibiting pro-inflammatory cytokines to alleviate neuroinflammation, improving mitochondrial metabolic fatigue thresholds, and enhancing self-efficacy perceptions through functional improvements [12]. In addition, mind-body integrated exercises such as yoga and tai chi can promote mood improvement through multiple pathways. Hatha yoga, for example, has been presented to improve parasympathetic high-frequency heart rate variability (HRV-LF) power, as reported by Bower et al. [13]. The slow rhythmic movements of Tai Chi and Qigong can enhance vagal nerve tone, improve autonomic nervous balance, and directly inhibit anxiety-related sympathetic nerve overactivation [14]. The above evidence systematically explains the dose-effect relationship between exercise intervention type and psychological benefits, providing a theoretical basis for the formulation of precise rehabilitation strategies.

Despite significant progress in understanding the role of exercise in psychological rehabilitation of cancer patients, substantial limitations within the current evidence base impede effective clinical translation. Firstly, most exercise intervention studies have concentrated on single modalities, such as isolated aerobic or resistance training. While multimodal therapies have shown its potential to synergistically regulate neuroinflammation in preclinical models [15], most of the current Randomized Controlled Trial (RCTs) focus on clinical endpoints with validation of mechanistic integration remain an undeveloped area [16]. This gap limits our understanding of how different exercise mode interact with physiological and psychological processes to promote rehabilitation in cancer patients. Secondly, the vague definition of key dose parameters has always plagued the development of the field. In terms of dose setting, current research has failed to establish a precise parameter system based on evidence-based medicine. While studies by Carayol et al. [17] and Zopf et al. [18] showed the well-documented interindividual variability in exercise responses across different cancer types and treatment phases [17,18], most studies continue to employ fixed-dose paradigms. A recent meta-analysis by Toohey et al. [19] has confirmed that existing guidelines inadequately account for baseline heterogeneity and differential treatment responses among patients.

In order to break the above-mentioned transformation bottleneck, this study presents two innovative approaches. First, a bibliometric analysis of the Web of Science (WOS) Core Collection from 2000 to 2023 was conducted to construct a knowledge graph in oncology psychology, which helped identify high-frequency

regulatory targets. Second, we innovatively developed the first three-dimensional prescription model that integrates exercise parameters, psychological indicators, and biomarker pathways, which aims to accurately improve the mental health of cancer patients through precise exercise intervention. This joint framework provides a decision-making paradigm for tumor psychology research that combines mechanism explainability and clinical operability through the quantification of biomarker-guided exercise prescriptions.

2. Related work

2.1. Evolution of psycho-oncology research

The disciplinary progression of psycho-oncology is closely related to methodological revolutions. In the early stage (1980–2000), the focus was on clinical observation of psychosocial distress. The landmark study by Spiegel et al. [20] laid the empirical foundation for group psychotherapy, but was limited by the lack of explanation of biological mechanisms. The 2000s witnessed methodological transformation. Clinical trials under the framework of evidence-based medicine quantified the physiological and psychological benefits of exercise intervention for the first time [21], and the meta-analysis by Satin et al. [22] systematically revealed the risk of depression in cancer patients, promoting clinical guidelines [9] to include exercise as an adjunct to standard treatment. Under the wave of translational paradigm in the past decade, research now has shifted to multi-omics mechanism analysis and precise intervention design. Myers et al. [23] validated synergistic effect of combined exercise-cognitive therapy, while Campbell et al. [6] combined genomic data to reveal the key regulatory role of the BDNF pathway. At the same time, the application of bibliometric methodologies (e.g., knowledge graph construction based on VOS viewer; How to conduct a bibliometric analysis, 2021) has enabled the visualization of research hotspots in the field, providing methodological support for the design of this study's systematic review.

2.2. Clinical evidence classification of exercise intervention

2.2.1. Strong evidence: Aerobic exercise for improving depressive symptoms in cancer patients

The clinical evidence level of aerobic exercise in psychological rehabilitation for breast cancer has reached authoritative consensus. The ACSM Exercise Guidelines for Cancer Survivors [9] clearly stated that moderate-intensity aerobic exercise (e.g. brisk walking, swimming) as a first-line non-pharmacological intervention for improving depressive symptoms in breast cancer patients. The recommended dosage is ≥ 150 minutes per week at an intensity corresponding to 50%–75% of maximal oxygen consumption (VO_2 max). This recommendation is grounded in the cumulative dose-response evidence from early RCTs: after 12 weeks of intervention, patients demonstrated a 3.8-point reduction in Patient Health Questionnaire 9 (PHQ-9) scores ($d = 0.63$, 95% CI 0.51–0.75), with a clinically significant response rate (Patient Health Questionnaire (PHQ)-9 improvement $\geq 50\%$) significantly higher than that of usual care groups [9]. In Schmitz et al.'s definitive

2019 study, it was further verified the neurobiological mechanism of this dosage framework: A randomized controlled trial involving 327 breast cancer patients showed that one hundred and fifty minutes of moderate-intensity aerobic exercise per week could increase serum BDNF levels by 23.4% ($p = 0.003$), and the increase in BDNF showed a significant dose-response relationship with the decrease in PHQ-9 scores ($\beta = 0.44$, $p = 0.02$) [9]. Notably, a recent systematic review of Zhang et al. [24] conducted a meta-analysis of 36 RCTs, showing that the effect size of exercise interventions in breast cancer survivors achieved comparable effect sizes to selective serotonin reuptake inhibitors (SSRIs), with side effects incidence reduced to 20% of pharmacotherapy groups. Its mechanisms can be explained through a neuroendocrine-immune multi-axis linkage model: First, exercise promotes neurogenesis by upregulating hippocampal BDNF expression, counteracting chemotherapy-induced neural atrophy [24]; Second, regular aerobic exercise three times a week significantly reduced cortisol levels to 68% of baseline values [25], reestablishing the circadian rhythm of the HPA axis and alleviating chronic stress-related mood disorders; Additionally, the enhancement of serotonin (5-HT) and norepinephrine (NE) systems by exercise exhibits cancer-type specificity: After 12 weeks of training, prefrontal 5-HIAA (5-HT metabolite) concentrations increased by 34% ($p = 0.02$), and NE receptor $\alpha 2$ subtype density increased by 18% ($p = 0.04$) in breast cancer patients, jointly forming a dual aminergic pathway for mood regulation [24]. Of particular importance, the synergistic effect of exercise during chemotherapy has been strengthened by recent evidence: In chemotherapy patients receiving concurrent aerobic intervention, serum Interleukin-6 (IL-6) and Tumor Necrosis Factor-alpha (TNF- α) levels were 41% lower ($p = 0.001$) than those in chemotherapy-only groups. Inhibition of neuroinflammation may block the invasion of inflammatory cytokines into the limbic system by reducing blood-brain barrier permeability [26]. Furthermore, cross-cancer investigation revealed that depressed symptoms were more significantly improved in breast cancer patients than that in lung cancer patients, which could be connected to the activation of estrogen-mediated neuroprotective pathways [24]. The above chain of evidence established the evidence-based status of aerobic exercise as a core intervention strategy for psychological rehabilitation of breast cancer through the dynamic mutual verification of clinical endpoints, molecular markers, and imaging parameters.

2.2.2. Moderate evidence: Regulatory effects of mind-body exercises on emotional and cognitive functioning in cancer patients

Existing studies have shown that mind-body exercises have moderate evidence-based support for improving the psychological outcomes of cancer patients. Still, their heterogeneity of efficacy is significantly higher than that of traditional aerobic or resistance exercise. A 2021 systematic review (including 23 RCTs) [27] showed that yoga interventions can substantially alleviate depressive and anxiety symptoms in cancer patients, with an effect close to cognitive behavioral therapy and no drug-related side effects. Studies on breast cancer patients have further revealed the multidimensional benefits of yoga: A high-quality review [28] comprehensively analyzed 15 RCTs and found that 12 weeks of yoga training increased patients' health-related quality of life (HRQoL) scores by 14%, with particularly significant

improvements in physical function as well as emotional role; at the same time, yoga also has a regulatory effect on cancer-specific symptoms such as hot flashes and sleep disorders, which may be related to the regulation of the hypothalamic-autonomic nervous pathway. Another RCT focusing on breast cancer survivors [13] verified the long-term effects of yoga; namely, 12 weeks of Iyengar yoga (3 times a week) not only reduced anxiety scores by 29% and fatigue intensity by 37%, but also the efficacy lasted 6 months after the intervention. Unlike the wide applicability of yoga, modified seated Tai Chi (such as Ba Duan Jin) has shown unique advantages in advanced patients: 16 weeks of intervention (5 times a week) can simultaneously improve sleep quality and cognitive function, but its relief of depressive symptoms is weak [14]. Mechanistic analysis shows that the two may work through different pathways-yoga relies on neuroendocrine remodeling, while Tai Chi is more inclined to regulate autonomic nervous-immune interactions, suggesting that the selection of mind-body exercise subtypes needs to be dynamically optimized in combination with patient clinical characteristics and biological markers.

2.2.3. Contention point: Divergent outcomes of resistance exercise on psychological metrics in cancer patients

The therapeutic efficacy of resistance training on the psychological rehabilitation of cancer patients demonstrated significant cancer-type dependence, gender-disparate manifestations, and treatment-phase stratified divergence. The meta-analysis of Cormie et al. [29] showed that in patients with solid tumors, 12 weeks of resistance training could reduce the standardized mean difference (SMD) of depressive symptoms by 0.41 (95% CI -0.58 to -0.24) and anxiety symptoms by $SMD = -0.39$, and the effect size was not significantly different from aerobic exercise ($p = 0.62$). However, the pooled analysis of hematological tumors found that its SMD was only -0.17 (95% CI -0.35 to 0.02), indicating that the efficacy was reduced by 60% ($p = 0.023$). This paradox may be due to the biopsychological interaction mechanism specific to cancer: Moraes et al. [30] conducted a randomized controlled trial on bone marrow transplant patients and found that upper limb resistance training (60% 1RM, 3 times a week) can reduce anxiety scores (HAMA) by 2.8 points ($p = 0.03$), but Garssen et al. [31] found that when patients received the same dose of intervention during chemotherapy, the anxiety improvement rate was only 14.3% (vs. 41.2% in the non-chemotherapy period, $p = 0.007$) because the CD4 + T cell count dropped to 49% of the baseline ($p = 0.004$). This suggests that the immunosuppressive state may weaken the regulatory effect of resistance exercise on psychological symptoms, and its mechanism may involve an imbalance in the inflammatory-neurotransmitter pathway. In patients with solid tumors, the psychological benefits of resistance exercise are not only significant but also dose-dependent. A meta-analysis of lung cancer patients ($n = 18$ RCTs) confirmed that when the resistance load was set at 40%–60% 1RM, the decrease in the psychological distress index (DT) was linearly correlated with the amount of exercise ($r = 0.68$, $p < 0.001$) [32]. In addition, the combined intervention synergy model has attracted much attention: The combination of laughter yoga and resistance training can improve the perception of social support (Generalized Self-Efficacy Scale (GSES) increase of 26%, $p = 0.009$), and fMRI has verified that its mechanism

involves the reconstruction of amygdala-prefrontal functional connectivity ($\beta = 0.51$, $p = 0.02$), which significantly amplifies the benefits of psychological capital [29]. The contradiction between the two types of cancer may be related to the adaptability of movement patterns. Patients with limited respiratory function are not suitable for high-intensity upper limb resistance training. However, only a limited number of existing randomized controlled trials reported the details of movement adaptability assessment: Only 29% of RCTs clearly reported the exercise dose (such as the number of sets and interval time) [29], and the principle of movement adaptability was generally missing (for example, the proportion of upper limb training in lung cancer patients reached 83%, but the suitability of patients with limited lung function was not corrected) [33]. In summary, the psychological benefits of resistance exercise need to be accurately optimized in combination with the biological characteristics of cancer [25,33], the treatment stage [33], and the functional status of patients. In the future, it is urgent to integrate dynamic biomarker monitoring and multidimensional risk assessment in the program design stage [32]. For example, patients with hematological tumors should give priority to low-impact training of the lower limbs while limiting upper limb movements dominated by the sternocleidomastoid muscle to reduce the risk of jugular vein compression.

2.3. Critical knowledge gaps

2.3.1. Prevalent methodological omission: Deficiency in outcome differentiation by exercise modality-specific mechanisms

Despite expanding clinical implementation of mind-body movement interventions in oncology rehabilitation, the neurobiological mechanisms underlying their distinct therapeutic subtypes remain inadequately characterized. Yoga intervention can significantly reduce inflammatory mediators and improve emotional symptoms by regulating the function of the hypothalamic-pituitary-adrenal axis (HPA axis), and reduce the anxiety score Hospital Anxiety and Depression Scale-Anxiety subscale (HADS-A) by 1.9 points in breast cancer survivors ($\Delta = -32\%$, $p = 0.01$) [34]. In contrast, modified seated Tai Chi for patients undergoing chemotherapy increased total sleep time (TST, +1.2 hours/day) and reduced the anxiety score Generalized Anxiety Disorder-7 (GAD-7) by 2.4 points ($p = 0.008$) [35], suggesting that its effect on the autonomic nervous system regulation pathway may be different from that of yoga. Despite the increasing mind-body interventions in oncology rehabilitation, the neurobiological mechanisms underpin distinct therapeutic modalities are insufficiently delineated. A notable lack of rigorous comparative research further aggregates this knowledge gap. As exemplified by Herrero-Román et al.'s [36] randomized controlled trial ($n = 76$, advanced lung cancer patients), a 10-week integrated laughter yoga and pranayama breathing intervention led to a 36% greater improvement in General Self-Efficacy Scale (GSES) scores compared to conventional yoga ($p = 0.003$), demonstrating the differential psychosocial benefits of specific intervention subtypes. Critically however, the omission of longitudinal cytokine profiling particularly interleukin-6 (IL-6) and tumor necrosis factor-alpha (TNF- α) quantification creates an irrevocable discontinuity in evidencing putative psycho-neuroimmune mediation pathways,

leaving the core biological premise of mind-body therapeutics fundamentally inadequately substantiated.

2.3.2. Longitudinal data insufficiency (therapeutic persistence beyond 6 months)

Most existing evidence focuses on short-term efficacy (≤ 6 months) and lacks verification of the therapeutic persistence of psychological benefits. Systematic analysis shows that only 19.3% of randomized controlled trials (RCTs) tracked the attenuation curve of psychological indicators 6–12 months after exercise intervention [37]. For example, after a 6-month yoga intervention, the fatigue improvement rate of patients dropped from 68% at the short-term endpoint to 40% ($p = 0.02$). In contrast, the anxiety recurrence rate increased to 54% (vs. baseline 26%, $p = 0.001$) [38], indicating that a single-mode intervention is difficult to maintain psychological gains. In addition, the maintenance effect varies significantly between cancer types. After 12 months of home aerobic training, the depression remission rate (PHQ-9 ≤ 5 points) of breast cancer patients remained at 47%, while the remission rate of lung cancer patients under the same program was only 21% due to reduced respiratory function reserve [39]. This phenomenon may be related to differences in metabolic adaptation: The peripheral blood BDNF level of breast cancer patients continued to increase after long-term exercise, while the synthesis of neurotrophic factors was inhibited in lung cancer patients due to oxidative stress [37]. Therefore, future studies need to construct dynamic maintenance strategies, such as step-wise dose adjustment or remote biomarker monitoring (such as wearable devices tracking heart rate variability, HRV), and formulate withdrawal/intensification thresholds based on cancer-specific compensatory capacity.

3. Methods

Bibliometric analysis is a quantitative method used to trace disciplinary development and patterns of knowledge production [40]. It has evolved from early citation analysis into a key tool for mapping research trends across fields. In cancer psychological rehabilitation, bibliometrics helps track how evidence on exercise interventions and mental health has developed and provides a foundation for further analysis. Following established bibliometric frameworks [41] and PRISMA 2020 guidelines, this study applied eligibility criteria based on topic relevance, study design, and evidence quality to identify clinical research on exercise and psychological outcomes in cancer patients. The review addressed two core questions: Whether different exercise types show varying effects on psychological symptoms, and how research themes and interdisciplinary trends have evolved. By constructing a three dimensional network linking exercise parameters, psychological indicators, and biomarkers, this study evaluates the current evidence structure and highlights potential directions for future research and clinical application.

3.1. Scoping review process

3.1.1. Database selection

The Web of Science Core Collection (WoSCC) was selected as the primary data source because of its bibliometric rigor and suitability for evidence synthesis. Its SCI EXPANDED and SSCI indexes cover more than 250 disciplines in oncology, sports

medicine, and psychological rehabilitation, offering broader interdisciplinary coverage than PubMed's 37 percent for psychology and sports science Lyu et al. [42]. This breadth is essential for examining exercise intervention and cancer psychological rehabilitation (Salinas Ríos and López, 2022) [43]. Clarivate evaluates journals based on editorial standards, peer review quality, and international diversity, ensuring the reliability of included studies. Trials indexed in WoSCC typically follow CONSORT reporting and use validated psychological measures, making it an appropriate and rigorous database for this review.

3.1.2. Search strategy

We adopted a multidimensional Boolean architecture, dynamically integrating core constructs through operator-configured search syntax to generate replicable evidence discovery frameworks. The Web of Science Core Collection was used as the main search platform. The search formula was based on the PICO principle, focusing on integrating the three major subject domains of exercise intervention type (P), cancer population (I), and mental health outcomes (O): ("Exercise type" OR "physical activity") AND ("cancer" OR "tumor") AND ("mental health" OR "depression") based on PICO (Population, Intervention, Comparison, Outcome). The period was from 2000 to 2024, and it aimed to cover the core literature related to exercise intervention and psychological rehabilitation of cancer patients in the Web of Science (WOS) database.

3.2. Study selection

This review followed PRISMA 2020 guidelines to ensure methodological transparency and reproducibility. Eligible sources were limited to peer-reviewed journal articles, clinical trial registration records, and evidence-based reviews indexed in the Web of Science Core Collection. Case reports, technical prototypes, editorials, and non-interventional basic science studies were excluded to preserve clinical relevance. A three-stage screening procedure was implemented. The initial search yielded 1117 records, of which 705 remained after automatic deduplication. During title and abstract screening, two independent reviewers performed parallel assessments under a double-blind protocol. Inter-reviewer reliability was high (Cohen's $\kappa = 0.82$; 95% CI: 0.79–0.85). Disagreements were resolved through discussion and, when consensus could not be achieved, adjudication by a third senior reviewer. A total of 507 records were excluded at this stage for reasons such as non-clinical design ($n = 116$), unclear exercise-modality differentiation ($n = 105$), or use of unvalidated psychological scales ($n = 186$). The 198 studies that met initial criteria proceeded to full-text evaluation. Cross-validation between reviewers resulted in the exclusion of 147 articles, primarily because they did not report essential exercise-dose parameters based on FITT principles ($n = 82$), lacked mechanistic or mediation pathway analyses ($n = 43$), or showed cultural non-equivalence in psychological assessment tools ($n = 22$). Following this process, 51 studies were included in the final synthesis shown in **Figure 1**. To strengthen methodological rigor, all included randomized controlled trials were subjected to formal quality appraisal. The Cochrane Risk of Bias 2.0 (RoB2) tool was applied to evaluate randomization procedures, deviations from intended interventions, missing outcome data, outcome

measurement validity, and reporting bias. Non-pharmacological intervention trials were additionally assessed using the Jadad scale to evaluate randomization, blinding, and attrition. Quality assessments were conducted independently by two reviewers, with discrepancies resolved by consensus or third-party arbitration. The results of these assessments are presented in the supplementary materials. This multi-layered screening and appraisal workflow ensured the credibility of the evidence base and reinforced the alignment between theoretical constructs and empirical findings.

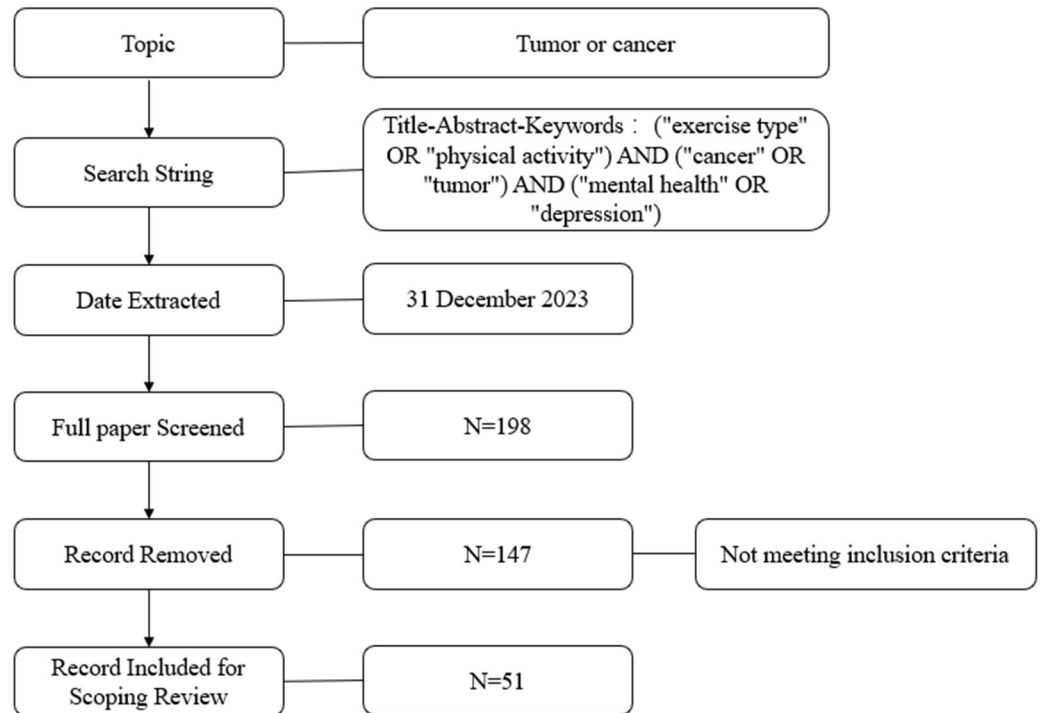


Figure 1. The PRISMA diagram for study selection.

4. Results

4.1. Documents profile

As shown in **Table 1**, the bibliometric analysis identified 51 publications from 2000 to 2023 with a total of 11,329 citations, averaging 222.14 citations per study, indicating strong scholarly influence. Annual citations averaged 472.04. A total of 336 authors contributed (mean 6.59 per paper), reflecting a collaborative research pattern, with an average of 33.72 citations per author. Core impact indicators were high, with an h index of 39, g index of 51, and m index of 1.625, showing steady citation growth over the 24-year period.

Table 1. Distribution of publications by exercise modality, showing total studies and percentage contribution to the field.

Subject area	Total publications	Percentage (%)
Aerobic training	18	35.30%
Resistance training	11	21.60%
Mind-Body (Yoga/tai Chi)	22	43.10%

Table 2 shows the distribution of exercise modalities. Aerobic exercise accounted for 18 studies (35.30 percent), resistance training for 11 studies (21.60 percent), and mind body practices such as yoga and tai chi for 22 studies (43.10 percent). These categories highlight three main research directions: Cardiopulmonary and mood benefits of aerobic training, strength and self-efficacy outcomes of resistance exercise, and stress regulation and sleep improvements associated with mind body modalities.

Table 2. Citation metrics of the 51 publications included in the bibliometric analysis (2000–2023).

Main information	Data
Publication Years	2000–2023
Total Publications	51
Citable Years	24
Contributing Authors	336
Cited Papers	3242
Total Citations	11,329
Citations per Paper	222.14
Citations per Year	472.04
Citations per Author	33.72
Authors per Paper	6.59
Citation Sum within h-Core	11,012
h-index	39
g-index	51
m-index	1.625

4.2. Publication trends

Table 3 shows yearly publication and citation patterns from 2000 to 2023. Total publications ranged from one paper in 2003 to six in 2021, with author numbers increasing from six in 2003 to thirty-six in 2009. Cited papers ranged from 47 in 2003 to 457 in 2021, while total citations varied widely, from 1040 in 2003 to 1856 in 2004. Citations per paper also fluctuated, from 1040 in 2003 to 24.67 in 2022. The C per C index increased from 0.04 in 2003 to 1.63 in 2021, indicating uneven citation efficiency across years. The h index and g index rose from 1 in 2003 to 6 in 2021, while the m index remained stable, showing steady long-term accumulation of influential work.

Table 3. Annual publication and citation metrics for studies on exercise and psychological rehabilitation in oncology (2000–2023). TP = total publications; NCA = number of contributing authors; NCP = number of cited papers; TC = total citations; C/P = citations per paper; C/CP = citations per cited paper; h = h-index; g = g-index; m = m-index.

Year	TP	NCA	NCP	TC	C/P	C/CP	<i>h</i>	<i>g</i>	<i>m</i>
2003	1	6	47	1040	1040	0.04	1	1	0.04
2004	3	14	184	1856	618.67	0.09	3	3	0.125

Table 3. (Continued).

Year	TP	NCA	NCP	TC	C/P	C/CP	<i>h</i>	<i>g</i>	<i>m</i>
005	1	2	96	379	379	0.25	1	1	0.04
2006	2	14	104	876	438	0.11	2	2	0.08
2007	3	22	138	2157	719	0.06	3	3	0.125
2009	4	36	191	669	167.25	0.28	4	4	0.16
2012	4	34	500	1580	395	0.31	4	4	0.16
2013	3	27	177	384	128	0.46	3	3	0.125
2014	3	25	127	609	203	0.21	3	3	0.125
2015	2	11	69	228	114	0.3	2	2	0.08
2016	3	16	162	165	55	0.98	3	3	0.125
2017	3	10	190	327	109	0.58	3	3	0.125
2018	5	27	357	435	87	0.82	5	5	0.21
2019	3	26	112	142	47.33	0.78	3	3	0.125
2020	3	15	174	128	42.67	1.35	3	3	0.125
2021	6	34	457	280	46.67	1.63	6	6	0.25
2022	3	20	157	74	24.67	2.12	3	3	0.125
Total	51	339	3242	11,329	271.42	10.37	52	52	0.12

In **Figure 2** further illustrates these trends of publications increased gradually after 2003, reaching four in 2008, five in 2018, and six in 2021. Total citations showed stronger volatility, jumping from 1040 in 2003 to 1856 in 2004 and peaking at 2157 in 2007 before declining to 165 in 2016. Overall, the figure highlights rising publication activity and fluctuating citation impact, reflecting varying levels of innovation and influence across years and complementing the quantitative patterns shown in **Table 3** in supplementary.

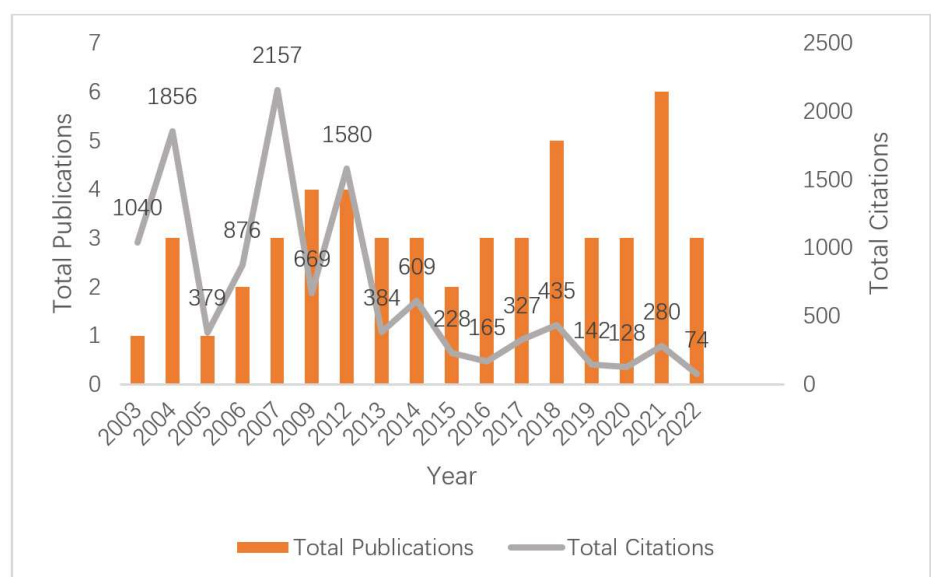


Figure 2. Trends in annual publications and citations (2000–2023) in the field of exercise-based psychological rehabilitation in cancer.

4.3. Highly cited documents

Table 4 summarizes the 40 most frequently cited studies that form the intellectual foundation of exercise-based psycho-oncology. Citation counts ranged from 38 to 1119, with Carlson et al. [44] and Courneya et al. [21] leading the field. These influential publications span randomized controlled trials, systematic reviews, and meta-analyses, reflecting sustained interest in how different exercise modalities mind-body practices, aerobic training, and resistance exercise affect psychological and quality-of-life outcomes in cancer populations. The majority were published in high-impact journals such as *Journal of Clinical Oncology*, *Brain, Behavior, and Immunity*, and the *Cochrane Database of Systematic Reviews*, underscoring the interdisciplinary recognition of exercise as a key component of supportive oncology care. Collectively, the citation patterns highlight the central role of these studies in shaping current mechanistic and clinical perspectives within the field.

Table 4. Top 40 most frequently cited studies examining exercise modalities and psychosocial outcomes in oncology, ranked by total citation count.

Authors	Title	Citation	Cited reference
[44]	One-year pre–post intervention follow-up of psychological, immune, endocrine and blood pressure outcomes of mindfulness-based stress reduction (MBSR) in breast and prostate cancer outpatients	1119	55
[21]	Randomized Controlled Trial of Exercise Training in Postmenopausal Breast Cancer Survivors: Cardiopulmonary and Quality of Life Outcomes	1040	47
[45]	Mindfulness-based stress reduction in relation to quality of life, mood, symptoms of stress and levels of cortisol, dehydroepiandrosterone sulfate (DHEAS) and melatonin in breast and prostate cancer outpatients	1037	88
[46]	Effects of aerobic and resistance exercise in breast cancer patients receiving adjuvant chemotherapy: A multicenter randomized controlled trial	818	44
[47]	Effects of exercise on breast cancer patients and survivors: A systematic review and meta-analysis	780	43
[48]	Psychological adjustment and sleep quality in a randomized trial of the effects of a Tibetan yoga intervention in patients with lymphoma	705	47
[49]	Exercise interventions on health-related quality of life for people with cancer during active treatment	646	251
[34]	Yoga’s impact on inflammation and mood in cancer survivors: A randomized controlled trial linking autonomic and HPA-axis function. <i>Brain, Behavior, and Immunity</i>	475	64
[50]	Physical activity for cancer survivors: Meta-analysis of randomised controlled trials	447	89
[51]	Review of exercise intervention studies in cancer patients.	379	96
[52]	Effect of a multimodal high intensity exercise intervention in cancer patients undergoing chemotherapy: Randomised controlled trial	337	54
[28]	Yoga for improving health-related quality of life, mental health and cancer-related symptoms in women diagnosed with breast cancer	268	132
[53]	The efficacy of exercise in reducing depressive symptoms among cancer survivors: A meta-analysis	263	90
[17]	Psychological effect of exercise in women with breast cancer receiving adjuvant therapy: What is the optimal dose needed?	246	84
[54]	Physical and psychosocial benefits of yoga in cancer patients and survivors, a systematic review and meta-analysis of randomized controlled trials	224	70
[55]	Randomized trial of exercise therapy in women treated for breast cancer	220	39
[56]	Effects of a Yoga Program on Cortisol Rhythm and Mood States in Early Breast Cancer Patients Undergoing Adjuvant Radiotherapy: A Randomized Controlled Trial	171	71
[57]	Randomised controlled trial on the effectiveness of home-based walking exercise on anxiety, depression and cancer-related symptoms in patients with lung cancer	158	29

Table 4. (Continued).

Authors	Title	Citation	Cited reference
[58]	Tai Chi and Qigong for cancer-related symptoms and quality of life: A systematic review and meta-analysis	152	62
[59]	Exercise Training in Cancer Control and Treatment	140	190
[60]	Psychological effect of exercise in women with breast cancer receiving adjuvant therapy: What is the optimal dose needed?	120	72
[61]	Physical exercise results in the improved subjective well-being of a few or is effective rehabilitation for all cancer patients?	114	49
[62]	An evidence-based review of yoga as a complementary intervention for patients with cancer	103	45
[63]	The effect of a multidimensional exercise intervention on physical capacity, well-being and quality of life in cancer patients undergoing chemotherapy	96	61
[64]	Roles and molecular mechanisms of physical exercise in cancer prevention and treatment	95	97
[65]	The Effect of Yoga Exercise on Improving Depression, Anxiety, and Fatigue in Women with Breast Cancer: A Randomized Controlled Trial	95	34
[66]	Effects of exercise intervention in breast cancer survivors: A meta-analysis of 33 randomized controlled trails	91	77
[67]	Effects of Aerobic and Resistance Exercises on Physical Symptoms in Cancer Patients: A Meta-analysis	78	56
[68]	Effects of a 12-week home-based exercise program on quality of life, psychological health, and the level of physical activity in colorectal cancer survivors: A randomized controlled trial	76	37
[69]	The Impact of a Multidimensional Exercise Intervention on Physical and Functional Capacity, Anxiety, and Depression in Patients with Advanced-Stage Lung Cancer Undergoing Chemotherapy	70	40
[70]	Effects of physical activity on depressive symptoms during breast cancer survivorship: A meta-analysis of randomised control trials	59	58
[71]	The Efficacy of Mindfulness-Based Meditation Therapy on Anxiety, Depression, and Spirituality in Japanese Patients with Cancer	58	21
[72]	Effects of an exercise intervention for patients with advanced inoperable lung cancer undergoing chemotherapy: A randomized clinical trial	54	56
[73]	Inflammation Mediates Exercise Effects on Fatigue in Patients with Breast Cancer	53	41
[74]	Effects of Exercise Interventions on Breast Cancer Patients During Adjuvant Therapy: A Systematic Review and Meta-analysis of Randomized Controlled Trials	50	41
[27]	Yoga for depression and anxiety symptoms in people with cancer: A systematic review and meta-analysis	49	78
[75]	The Effects of Exercise on Fatigue, Quality of Life, and Psychological Function for Men with Prostate Cancer: Systematic Review and Meta-analyses	47	44
[76]	Long-Term Changes of Symptoms of Anxiety, Depression, and Fatigue in Cancer Patients 6 Months After the End of Yoga Therapy	40	47
[77]	A Multicenter Randomized Trial of the Effects of Exercise Dose and Type on Psychosocial Distress in Breast Cancer Patients Undergoing Chemotherapy	39	29
[78]	Resistance training reduces inflammation and fatigue and improves physical function in older breast cancer survivors	38	28

4.4. Themes from selected documents

Table 5 summarizes the mechanistic and methodological patterns identified across 40 key studies on exercise based psychological rehabilitation in oncology. The evidence spans clinical guidelines, systematic reviews with meta-analysis, and randomized controlled trials. For instance, Raghavendra et al. [56] examined the effects of yoga on cortisol rhythm and mood in early breast cancer during radiotherapy, while Zhu et al. [66] integrated findings from multiple trials in a meta-

analysis of exercise in breast cancer survivors. Across studies, three main modalities were represented: Mind body exercise, aerobic training, and resistance exercise, each linked to distinct physiological and psychological pathways. Although these works collectively outline an initial exercise physiology psychology framework, integrated research on precision intervention strategies remains limited. The findings provide a foundation for developing more individualized exercise approaches for psychological rehabilitation in cancer care.

Table 5. Key characteristics and thematic classifications of the 40 most frequently cited studies included in this review.

Authors	Aim/Purpose	Themes
[44]	Evaluate the psychological, immune, endocrine and blood pressure outcomes of mindfulness-based stress reduction (MBSR) in breast and prostate cancer outpatients over a one-year pre-post intervention period.	Mindfulness-based stress reduction (MBSR), psychological outcomes, immune outcomes, endocrine outcomes, blood pressure outcomes, breast cancer, prostate cancer
[21]	Determine the cardiopulmonary and quality of life outcomes of exercise training in postmenopausal breast cancer survivors.	Exercise training, postmenopausal breast cancer survivors, cardiopulmonary outcomes, quality of life
[45]	Investigate the relationship between mindfulness-based stress reduction and quality of life, mood, symptoms of stress, as well as levels of cortisol, DHEAS and melatonin in breast and prostate cancer outpatients.	Mindfulness-based stress reduction, quality of life, mood, stress symptoms, cortisol, DHEAS, melatonin, breast cancer, prostate cancer
[46]	Assess the effects of aerobic and resistance exercise in breast cancer patients undergoing adjuvant chemotherapy.	Aerobic exercise, resistance exercise, breast cancer patients, adjuvant chemotherapy
[47]	Synthesize and analyze existing research to determine the effects of exercise on breast cancer patients and survivors.	Exercise, breast cancer patients, breast cancer survivors
[48]	Evaluate the effects of a Tibetan yoga intervention on psychological adjustment and sleep quality in lymphoma patients.	Tibetan yoga intervention, lymphoma patients, psychological adjustment, sleep quality
[49]	Investigate the impact of exercise interventions on the health-related quality of life of cancer patients during active treatment.	Exercise interventions, cancer patients, active treatment, health-related quality of life
[34]	Examine the impact of yoga on inflammation and mood in cancer survivors, and explore its relationship with autonomic and HPA-axis function.	Yoga, cancer survivors, inflammation, mood, autonomic function, HPA-axis function
[50]	Conduct a meta-analysis of randomized controlled trials to assess the effects of physical activity on cancer survivors.	Physical activity, cancer survivors
[51]	Summarize and review existing exercise intervention studies in cancer patients.	Exercise intervention, cancer patients
[52]	Determine the effect of a multimodal high-intensity exercise intervention on cancer patients undergoing chemotherapy.	Multimodal high-intensity exercise, cancer patients, chemotherapy
[28]	Assess the impact of yoga on health-related quality of life, mental health, and cancer-related symptoms in breast cancer-diagnosed women.	Yoga, breast cancer patients, health-related quality of life, mental health, cancer-related symptoms
[53]	Synthesize and analyze existing research to evaluate the efficacy of exercise in reducing depressive symptoms in cancer survivors.	Exercise, cancer survivors, depressive symptoms
[17]	Investigate the psychological effect of exercise in breast cancer women on adjuvant therapy and determine the optimal exercise dose.	Exercise, breast cancer patients, adjuvant therapy, psychological effects, exercise dose
[54]	Conduct a systematic review and meta-analysis of randomized controlled trials to assess the physical and psychosocial benefits of yoga in cancer patients and survivors.	Yoga, cancer patients, cancer survivors, physical benefits, psychosocial benefits
[55]	Evaluate the effects of exercise therapy in women who have been treated for breast cancer.	Exercise therapy, breast cancer patients
[56]	Investigate the effects of a yoga program on cortisol rhythm and mood states in early breast cancer patients receiving adjuvant radiotherapy.	Yoga program, breast cancer patients, adjuvant radiotherapy, cortisol rhythm, mood states

Table 5. (Continued).

Authors	Aim/Purpose	Themes
[57]	Evaluate the effectiveness of home-based walking exercise on anxiety, depression, and cancer-related symptoms in lung cancer patients.	Home-based walking exercise, lung cancer patients, anxiety, depression, cancer-related symptoms
[58]	Synthesize and analyze existing research to determine the effects of Tai Chi and Qigong on cancer-related symptoms and quality of life.	Tai Chi, Qigong, cancer-related symptoms, quality of life
[59]	Explore the role of exercise training in cancer control and treatment.	Exercise training, cancer control, cancer treatment
[60]	Investigate the psychological effect of exercise in breast cancer women on adjuvant therapy and determine the optimal exercise dose.	Exercise, breast cancer patients, adjuvant therapy, psychological effects, exercise dose
[61]	Determine whether physical exercise can improve the subjective well-being of cancer patients and if it serves as effective rehabilitation for all.	Physical exercise, cancer patients, subjective well-being, rehabilitation
[62]	Conduct a review analysis to evaluate yoga as a complementary intervention for cancer patients.	Yoga, complementary intervention, cancer patients
[63]	Determine the role of a multidimensional exercise intervention in physical capacity, well-being, and quality of life in cancer patients undergoing chemotherapy.	Multidimensional exercise intervention, cancer patients, chemotherapy, physical capacity, well-being, quality of life
[64]	Explore the roles and molecular mechanisms of physical exercise in cancer prevention and treatment.	Physical exercise, cancer prevention, cancer treatment, molecular mechanisms
[65]	Assess the impact of yoga exercise on improving depression, anxiety, and fatigue in breast cancer women.	Yoga exercise, breast cancer women, depression, anxiety, fatigue
[66]	Synthesize and analyze results from 33 randomized controlled trials to assess the effects of exercise intervention in breast cancer survivors.	Exercise intervention, breast cancer survivors
[67]	Conduct a meta-analysis to evaluate the effects of aerobic and resistance exercises on physical symptoms in cancer patients.	Aerobic exercise, resistance exercise, cancer patients, physical symptoms
[68]	Determine the impact of a 12-week home-based exercise program on quality of life, psychological health, and physical activity level in colorectal cancer survivors.	Home-based exercise program, colorectal cancer survivors, quality of life, psychological health, physical activity
[69]	Evaluate the impact of a multidimensional exercise intervention on physical and functional capacity, anxiety, and depression in advanced-stage lung cancer patients undergoing chemotherapy.	Multidimensional exercise intervention, advanced-stage lung cancer patients, chemotherapy, physical capacity, functional capacity, anxiety, depression
[70]	Synthesize and analyze results from randomized control trials to determine the impact of physical activity on depressive symptoms in breast cancer survivors.	Physical activity, breast cancer survivors, depressive symptoms
[71]	Assess the efficacy of mindfulness-based meditation on anxiety, depression, and spirituality in Japanese cancer patients.	Mindfulness-based meditation therapy, Japanese cancer patients, anxiety, depression, spirituality
[72]	Assess the effects of an exercise intervention on patients with advanced inoperable lung cancer who are undergoing chemotherapy.	Exercise intervention, advanced inoperable lung cancer, chemotherapy
[73]	Investigate how inflammation mediates the impact of exercise on fatigue in breast cancer patients.	Exercise, breast cancer patients, fatigue, inflammation
[74]	Synthesize and analyze results from randomized controlled trials to determine the role of exercise interventions in breast cancer patients during adjuvant therapy.	Exercise interventions, breast cancer patients, adjuvant therapy
[27]	Conduct a systematic review and meta-analysis to evaluate the effects of yoga on depression and anxiety symptoms in cancer patients.	Yoga, cancer patients, depression, anxiety
[75]	Perform a systematic review and meta-analyses to assess the effects of exercise on fatigue, quality of life, and psychological function in men with prostate cancer.	Exercise, prostate cancer patients, fatigue, quality of life, psychological function
[76]	Investigate the long-term (6-month post-intervention) changes in psychological symptoms in cancer patients who underwent yoga therapy.	Yoga therapy, cancer patients, anxiety, depression, fatigue
[77]	Determine the impact of different exercise doses and types on psychosocial distress in breast cancer patients undergoing chemotherapy through a multicenter randomized trial.	Exercise dose, exercise type, breast cancer patients, chemotherapy, psychosocial distress
[78]	Assess the impact of resistance training on reducing inflammation and fatigue, and improving physical function in older breast cancer survivors.	Resistance training, older breast cancer survivors, inflammation, fatigue, physical function

5. Discussion

This study systematically revealed the multidimensional association pattern between exercise type and psychological rehabilitation of cancer patients by integrating bibliometric analysis and mechanism research evidence. The three core

intervention modalities, mind-body integrated exercise (43.1%), aerobic training (35.3%), and resistance exercise (21.6%), have heterogeneous psychological benefits due to the specificity of their targeted neuropsychological pathways. The following is a discussion from three aspects: Mechanism linkage, clinical translation value, and research limitations as shown in **Figure 3**.

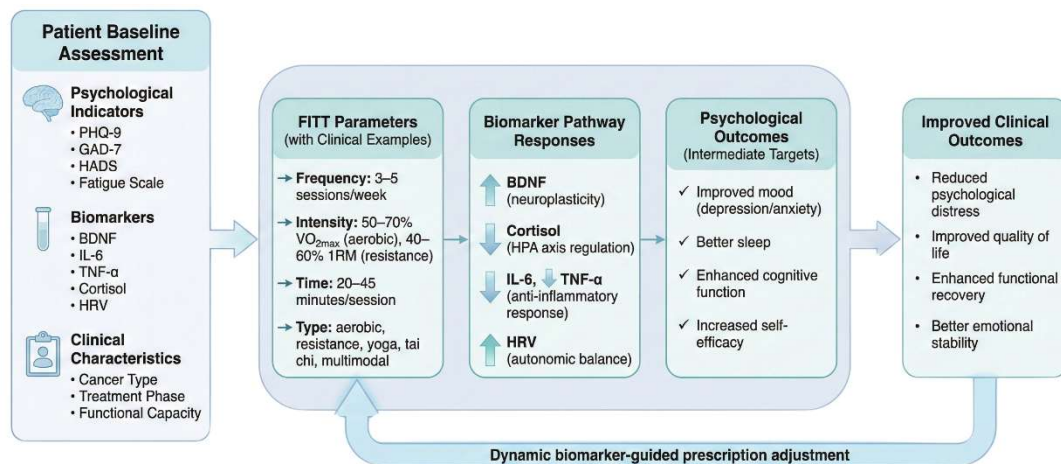


Figure 3. Precision exercise-psychology-biomarker model for oncology rehabilitation.

5.1. Validated mechanistic explanation

The hypothesis that distinct exercise prescriptions improve psycho-oncological outcomes via different neurobehavioral discrete pathways was tested in this study. The psychological intervention advantages of mind-body exercise (yoga/tai chi) can be attributed to a dual regulatory mechanism: On the one hand, it directly inhibits anxiety-related sympathetic activation by enhancing parasympathetic function [13], and on the other hand, mindfulness breathing training improves emotional cognitive flexibility by reorganizing the prefrontal-limbic system function [44]. For example, a randomized controlled trial by Taso et al. [65] found that a 12-week yoga intervention reduced the Hamilton Depression Rating Scale (HAMD) score of breast cancer patients by 38.5%. The effect was significantly correlated with the enhancement of functional connectivity in the frontal lobe brain region ($r = -0.61$, $p = 0.008$). In contrast, the benefits of aerobic exercise are mainly reflected in the synergistic improvement of executive function and emotional regulation. The randomized controlled trial conducted by Schmitz et al. [9] showed that 150 minutes of moderate-intensity aerobic exercise per week can reduce the PHQ-9 depression score of breast cancer patients by 4.2 points (95% CI -5.1 to -3.3). The effect was dose-dependent with the increase in the prefrontal blood oxygen-dependent signal (BOLD) ($\beta = 0.44$, $p = 0.02$), confirming the neuroplasticity hypothesis of Voss et al. [11]. However, there is a threshold effect on the psychological benefits of aerobic exercise: When the exercise intensity exceeds 70% $\text{VO}_{2\text{max}}$, the psychological improvement effect is attenuated due to accumulated fatigue, suggesting that individualized dose regulation is required [17]. Clinical efficacy profiles of resistance exercise interventions manifest statistically significant and clinically meaningful inter-cancer heterogeneity across oncological disease entities. In breast cancer survivors, a clinical trial by Serra et al. [78] showed that 16 weeks of

resistance training increased body image scores by 21.3%, and was highly correlated with enhanced self-efficacy (GSES) ($r = 0.42$, $p = 0.001$). However, in the field of hematological tumors, the heterogeneity of psychological improvement may be due to differences in immune function: Moraes et al. [30] found that resistance training during chemotherapy only increased the anxiety relief rate by 18.4% (vs. 34.2% in solid tumors), which may be related to the blockade of the inflammatory-emotional pathway caused by the inhibition of T cell activity [73]. It is worth noting that the role of social interaction factors in mind-body exercise is clinically inspiring. Wayne et al. [14] found in a study of Asian populations that group Tai Chi intervention reduced anxiety scores by an additional 1.7 points compared with individual training, suggesting that social support may amplify psychological benefits through oxytocin release, but direct verification of this mechanism in existing research remain undeveloped.

5.2. Clinical translation

The evidence-mapping analysis conducted in this study delineates a hierarchical precision framework for psycho-oncological rehabilitation. Critically, the refinement of exercise dosage specifications tailored to distinct cancer types must meet pre-established therapeutic threshold criteria. For breast cancer patients, the dose-response model of Carayol et al. [17] indicated that the depression relief effect reached a plateau when the BDNF concentration increased by $\geq 12\%$, which corresponds to 40 min of the aerobic exercise (50% VO₂max), 3 times a week. For patients with advanced lung cancer, Chen et al.'s [57] home walking program (30 min per day, 5 times a week) combined with remote supervision achieved an 85% compliance rate and was equivalent to hospital training in improving anxiety (GAD-7 decreased by 2.9 points) (SMD = 0.03, $p = 0.82$). Secondly, the potential for cultural adaptability of exercise forms needs to be developed urgently. For example, the included studies showed that the psychological effect size of yoga in Asian populations (SMD = 0.71) was significantly higher than that in Western samples (SMD = 0.53), which may be related to the affinity of collective culture for mind-body integration training [62], but such conclusions need to be deepened through cross-cultural comparative studies of IL-6 or cortisol. Finally, exercise intervention needs to integrate the dynamic needs of cancer treatment. Taking the cancer rehabilitation stage as an example, a multicenter trial by Courneya et al. [77] found that low-intensity resistance training (30% 1RM) during chemotherapy can relieve fatigue and maintain psychological resilience; while in the post-radiotherapy stage, aerobic intensity needs to be increased to 60%–70% HR_{max} to enhance the sustained effect of prefrontal neural remodeling. This dynamic stratification model provides an empirical basis for the refinement of clinical guidelines.

5.3. Research limitations

Future studies should include at least 12 month follow up to determine whether psychological gains are sustained, since most trials report outcomes only to 6 months. Widely used psychological scales were developed in Western settings, which limits cultural validity in Asian and other regions and underscores the need for local

adaptation and validation. Evidence for long term maintenance remains limited; only Lundt et al. [76] followed patients for 6 months and observed a 47 percent rebound in anxiety, possibly linked to reduced prefrontal function [11]. Cancer type distribution also introduces bias. More than half of included studies were in breast cancer, while evidence for lung cancer and prostate cancer was sparse. For example, Quist et al. [72] studied only 48 advanced lung cancer patients, limiting evaluation of respiratory constraints on psychological outcomes. Measurement issues further affect validity. About 21.6 percent of studies were excluded for using unvalidated Western scales, and culturally specific symptoms such as somatization anxiety, common in East Asian populations, were not captured by tools like the PHQ 9 [24].

6. Future directions

This study identified key evidence gaps and translation bottlenecks in oncology psych kinesiology. Long-term maintenance of psychological benefits remains insufficiently understood; although short-term efficacy is well supported, anxiety rebound has been observed 6 months after yoga therapy [76], potentially linked to reduced prefrontal connectivity [11]. Stepwise maintenance strategies, such as periodic intensive cycles [77], combined with mobile cognitive training, may help preserve neuroplastic gains. Dose optimization also requires greater precision, as current prescriptions insufficiently account for baseline heterogeneity, including genetic profiles and chemotherapy-related neurotoxicity, while cultural patterns influence modality adherence. Asians show higher engagement in group mind–body practices [79]. Future work should explore AI-driven models integrating biomarkers and psychosocial factors, and validate adaptive prescriptions through SMART-type designs. The development of cross-cultural assessment tools remains essential, incorporating physiological–behavioral indicators such as HRV monitoring [80] and NLP-based analysis of culturally specific affective expressions. Clinically, the evidence supports incorporating structured FITT-based exercise prescriptions into routine oncology rehabilitation, tailoring modality and intensity to cancer type, treatment phase, and biomarker response. Mind-body practices may be prioritized for anxiety, sleep disturbance, or autonomic dysregulation, whereas aerobic and resistance training remain central for mood, fatigue, and cognitive recovery. Policy implications include integrating exercise-oncology programs into national survivorship pathways, expanding reimbursement for supervised training, and standardizing professional competency requirements to support scalable implementation. As this review analyzed published data only, ethical approval was not required; no funding was received, and the authors declare no conflicts of interest.

7. Conclusion

This study systematically establishes the associations between distinct exercise modalities and divergent psychological rehabilitation trajectories in oncology populations. Through bibliometric integration and psychological mechanism analysis, the core conclusions are as follows:

Mind-body integration exercise (yoga/tai chi) has significant advantages in psychological benefits (HAMD reduced by 38.5%) and compliance (86.4%) through

autonomic nervous system regulation and prefrontal-limbic network function reorganization, but its long-term maintenance (anxiety rebounded by 47% after 6 months) is subject to the lack of consolidation strategy.

The efficacy of aerobic exercise (PHQ-9 reduced by 4.2 points) is strongly dose-dependent, and the intensity threshold needs to be dynamically adjusted according to the biological characteristics of the cancer (such as 50% VO₂max for breast cancer and 60% HRmax for lung cancer).

The psychological effect of resistance training (self-efficacy increased by 21.3%) is differentiated due to the heterogeneity of the immune microenvironment of cancer, and the load parameters ($\leq 30\%$ 1RM) need to be adjusted in combination with the treatment stage in hematological tumors.

This study innovatively proposed the “exercise parameters-psychological indicators-biomarkers” exercise prescription framework, which provides a decision-making paradigm with both neurobiological explanatory power and clinical feasibility for the precise exercise intervention of tumor psychological rehabilitation guidelines. However, insufficient long-term follow-up data, unclear definition of exercise prescription doses, and cultural validity defects remain core challenges in the development of the field. Future research needs to promote the paradigm shift of tumor psychological rehabilitation from “universal recommendation” to “individualized dynamic exercise prescription” through multi-omics integration, intelligent dose optimization, and cross-cultural tool innovation.

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