European Journal of Public Health Studies
ISSN: 2668 - 1056
ISSN-L:2668 - 1056
Available on-line at: www.oapub.org/hlt

DOI: 10.46827/ejphs.v9i1.256 Volume 9 │ Issue 1 │ 2026

EXERCISE ONCOLOGY AND LIFESTYLE MEDICINE: PHYSICAL ACTIVITY AS AN ADJUNCT IN CANCER PREVENTION AND SURVIVORSHIP CARE

Phemyaphat Singto[i]
MD,
Department of Medicine,
Bangkok Hospital Pattaya,
Pattaya, Chonburi,
Thailand

Abstract:

Background: Cancer is a leading cause of mortality worldwide, with over 19.3 million new cases diagnosed annually. Despite advances in oncological treatment, growing evidence demonstrates that physical activity plays a clinically significant role across the entire cancer continuum—from primary prevention to peri-treatment management and long-term survivorship. Exercise oncology has emerged as a critical discipline within lifestyle medicine. **Objective:** To synthesize current evidence on the role of physical activity as a therapeutic and preventive adjunct in cancer care, encompassing cancer prevention, prehabilitation, peri-treatment exercise, survivorship, and the underlying molecular mechanisms. **Methods:** A narrative review of peer-reviewed literature was conducted using PubMed, Scopus, and Google Scholar. Key terms included 'exercise oncology,' 'physical activity cancer prevention,' 'cancer survivorship exercise,' 'myokines cancer,' and 'exercise prehabilitation.' Priority was given to randomized controlled trials, systematic reviews, meta-analyses, and landmark studies published from 2010 to 2026. **Results:** Physical activity reduces the risk of at least 13 types of cancer. The landmark CHALLENGE Trial (NEJM, 2025) demonstrated that a 3-year structured exercise program after adjuvant chemotherapy for colon cancer reduced disease-free survival events by 28% (HR 0.72) and improved overall survival. Exercise during and after cancer treatment improves cardiorespiratory fitness, reduces cancer-related fatigue, alleviates depression and anxiety, prevents sarcopenia, and enhances quality of life. Mechanistically, exercise induces anti-tumor myokines (CXCL1, irisin, SPARC, IL-10), remodels the tumor immune microenvironment, and modulates systemic inflammatory pathways. **Conclusion:** Physical activity should be considered a core therapeutic modality in oncological care, integrated across prevention, prehabilitation, active treatment, and survivorship. Clinicians should adopt an Assess–Advise–Refer model,

[i] Correspondence: phemyaphat.s@gmail.com

prescribing individualized exercise programs using FITT principles with cancer-specific modifications.

Keywords: exercise oncology; physical activity; cancer survivorship; myokines; prehabilitation; lifestyle medicine; CHALLENGE trial

1. Introduction

Cancer remains one of the most prevalent and lethal non-communicable diseases worldwide, with GLOBOCAN 2022 reporting over 19.3 million new cases and approximately 10 million cancer-related deaths annually.1 Advances in early detection and systemic therapies have led to dramatically improved survival rates across major cancer subtypes, generating a rapidly growing population of cancer survivors who require evidence-based, long-term supportive care.[2] In the United States alone, the cancer survivor population is projected to reach 22.5 million by 2032, with over 75% of patients surviving five or more years after diagnosis.[3]

Historically, cancer survivors were counseled to rest and avoid physical exertion following treatment. This paradigm has undergone a fundamental transformation over the past two decades. A substantial and growing body of evidence now demonstrates that regular physical activity—when appropriately prescribed—is not only safe but profoundly beneficial at every stage of the cancer continuum: from primary prevention, to surgical prehabilitation, to peri-treatment support, to long-term survivorship care.4 The American Society of Clinical Oncology (ASCO), the American College of Sports Medicine (ACSM), and the National Comprehensive Cancer Network (NCCN) have each formalized recommendations integrating exercise into oncological practice.[5,8,10,22]

The concept of exercise oncology—the application of exercise science to cancer prevention and care—has emerged as a critical discipline within lifestyle medicine. The six pillars of lifestyle medicine (nutrition, physical activity, sleep, stress management, avoidance of risky substances, and social connection) each contribute to cancer outcomes; however, physical activity occupies a uniquely powerful position by virtue of its multifaceted mechanistic effects on tumor biology, immune function, cardiometabolic health, and psychological well-being.[4,5]

This narrative review synthesizes the current evidence on physical activity across the cancer care continuum, with particular emphasis on recent landmark clinical trial data, molecular mechanisms, practical prescriptive frameworks, and implications for lifestyle medicine practice.

2. Physical Activity and Cancer Prevention

The evidence linking regular physical activity to reduced cancer incidence is robust and dose-dependent. A landmark pooled analysis by Moore et al. (2016), encompassing 1.44 million adults from the United States and Europe, demonstrated that higher leisure-time physical activity was associated with significantly lower risks across 13 of 26 cancer types examined, including reductions in colon cancer (HR 0.84), breast cancer (HR 0.90), endometrial cancer (HR 0.79), kidney cancer (HR 0.77), and bladder cancer (HR 0.85).[6]

Mechanistically, physical activity reduces cancer risk through several interconnected pathways: reduction of adiposity and systemic inflammation, improvement of insulin sensitivity, reduction of circulating insulin-like growth factor-1 (IGF-1), modulation of sex hormone levels (particularly estrogen), enhancement of immune surveillance, and acceleration of gastrointestinal transit time.[7] Furthermore, Friedenreich et al. (2021) highlighted that physical inactivity and obesity together account for a substantial proportion of attributable cancer risk in high-income countries, reinforcing lifestyle medicine's relevance in oncological prevention.[7]

Current recommendations from the World Health Organization (WHO) and ACSM advise adults to accumulate at least 150–300 minutes of moderate-intensity or 75–150 minutes of vigorous-intensity aerobic physical activity per week, alongside muscle-strengthening activities on two or more days per week.[3] For cancer prevention specifically, higher volumes (300+ minutes of moderate activity per week) appear to confer additional risk reduction.[8] Sedentary behavior represents an independent risk factor, with prolonged sitting time associated with elevated cancer mortality even among individuals who meet physical activity guidelines.[9]

3. Exercise and Cancer Prehabilitation

3.1 The Concept of Prehabilitation

Prehabilitation refers to the process of enhancing a patient's functional reserve capacity before the anticipated physiological stress of cancer surgery, chemotherapy, or radiation.[23] The rationale is straightforward: patients with superior preoperative cardiorespiratory fitness and muscle strength tolerate treatment more effectively, experience fewer complications, and recover more rapidly.[24] The available 'window' between cancer diagnosis and the initiation of treatment—typically ranging from two to eight weeks—presents a critical but often underutilized opportunity for targeted exercise intervention.[25]

3.2 Evidence for Prehabilitation

A randomized controlled trial by Minnella et al. (2018) demonstrated that a multimodal prehabilitation program comprising aerobic exercise, resistance training, and nutritional optimization significantly improved functional walking capacity at four weeks after esophagogastric cancer surgery compared with rehabilitation alone.[26] Similarly, systematic reviews consistently report that prehabilitation reduces postoperative complications, shortens hospital length of stay, and accelerates return to baseline function across colorectal, lung, and abdominal cancer surgeries.[23,25]

The ACSM's Moving Through Cancer program, updated in 2025, now formally incorporates prehabilitation as a standard component of exercise oncology, recommending that clinicians assess functional capacity at diagnosis and implement structured exercise programs prior to surgery and/or systemic therapy.14 Digital health applications for prehabilitation exercise delivery have demonstrated feasibility and user acceptance in pilot studies (Zhang et al., 2025), suggesting scalable implementation potential for resource-limited settings.[43]

4. Exercise During Active Cancer Treatment

4.1 Safety and Tolerability

A persistent misconception among oncologists and patients alike is that exercise during active cancer treatment is unsafe or counterproductive. Multiple systematic reviews and meta-analyses have conclusively demonstrated that supervised aerobic and resistance exercise is safe and well-tolerated during chemotherapy, radiation therapy, and hormonal treatment in the majority of cancer patients without bone metastases, severe anemia, or uncorrected cardiopulmonary dysfunction.[13,14,21]

Pre-exercise screening using validated tools such as the Physical Activity Readiness Questionnaire (PAR-Q) and cancer-specific checklists from the ACSM roundtable guidelines is recommended to identify individuals requiring medical clearance or modified exercise programs.[13] Special considerations include monitoring for cardiotoxicity with anthracycline-based regimens, avoiding high-impact exercise with thrombocytopenia or bone metastases, and implementing infection-control measures in immunocompromised patients.[14,36]

4.2 Cancer-Related Fatigue

Cancer-related fatigue (CRF) is the most prevalent and debilitating symptom reported by cancer patients, affecting up to 90% of those undergoing treatment.46 A landmark meta-analysis by Mustian et al. (2017), analyzing 113 randomized controlled trials involving 11,525 cancer patients, demonstrated that exercise was more effective than both pharmaceutical interventions (e.g., methylphenidate, modafinil) and psychological therapies in reducing CRF.47 Aerobic exercise, resistance training, and combined modalities each produced clinically significant reductions in fatigue severity, with effects maintained over follow-up periods.

4.3 Psychological Outcomes

A systematic review and meta-analysis by Soong et al. (JAMA Network Open, 2025), specifically examining older adults with cancer, found that exercise interventions produced statistically significant and clinically meaningful reductions in depression and anxiety, alongside improvements in quality of life (QoL) across multiple cancer types.[15] Exercise appears to exert its psychological effects through neuroendocrine modulation (reduction of cortisol, increase of endorphins and brain-derived neurotrophic factor [BDNF]), improvement of self-efficacy, and enhancement of social engagement through group-based programs.[40,49]

4.4 Cardiorespiratory Fitness

Cancer therapy—particularly anthracycline-based chemotherapy, targeted HER2 agents, and mediastinal radiation—is associated with progressive cardiorespiratory deconditioning and increased long-term cardiovascular risk.[37] A systematic review by Scott et al. (2018) demonstrated that structured exercise programs significantly improved peak oxygen uptake (VO2 peak) in cancer patients, with effects comparable to cardiac rehabilitation programs.[38] Preserving cardiorespiratory fitness during treatment has been independently associated with improved overall survival across multiple cancer types.[36]

5. Exercise in Cancer Survivorship

5.1 The CHALLENGE Trial: A Paradigm Shift

The publication of the CHALLENGE Trial in the New England Journal of Medicine on June 1, 2025, represents the most significant milestone in exercise oncology to date.[11] The Canadian Cancer Trials Group CO.21 study enrolled 889 patients with stage II (high-risk) or stage III colon cancer who had completed adjuvant chemotherapy across 55 centers in six countries between 2009 and 2024. Participants were randomized to either a structured 3-year aerobic exercise program targeting ≥10 metabolic equivalent of task (MET)-hours per week (equivalent to brisk walking 3–4 times per week for 45–60 minutes), or health education materials alone.

At a median follow-up of 7.9 years, the exercise group demonstrated a 28% reduction in disease-free survival (DFS) events compared to the control group (HR 0.72; 95% CI, 0.55–0.94). The 5-year DFS rate was 80.3% in the exercise group versus 73.9% in the health education group—a clinically and statistically significant difference of 6.4 percentage points.[11,12] Findings were consistent with a benefit in overall survival. Importantly, the magnitude of benefit conferred by structured exercise was comparable to several adjuvant pharmacological interventions currently in standard oncological practice.

The CHALLENGE Trial provides the first robust, level 1 randomized evidence that a structured exercise program can significantly improve cancer survival outcomes. It fundamentally reframes exercise from a 'nice-to-have' lifestyle recommendation to a necessity in standard oncological care, and has major implications for how exercise oncology is integrated into clinical practice guidelines globally.[12]

5.2 Additional Evidence in Cancer Survivorship

Beyond the CHALLENGE Trial, evidence supporting exercise in survivorship is extensive. Systematic reviews consistently demonstrate that post-treatment physical activity is associated with 25–40% reductions in cancer-specific and all-cause mortality for survivors of early-stage breast, colorectal, and prostate cancers.[8,10] A network meta-analysis by Zhang et al. (2025) compared different exercise modalities—aerobic, resistance, combined, mind-body—and found that combined aerobic and resistance exercise produced the greatest reductions in inflammatory markers and the most robust enhancements in immune function, including natural killer (NK) cell activity and cytotoxic T-lymphocyte proliferation.[32]

For breast cancer specifically, recreational physical activity post-diagnosis was associated with a 30–50% reduction in recurrence risk in a meta-analysis by Zagalaz-Anula et al. (2022).[50] Lahart et al. (2018) demonstrated in a Cochrane systematic review that physical activity programs improved physical functioning, QoL, and body weight in breast cancer survivors following adjuvant therapy.[48]

6. Molecular Mechanisms: How Exercise Suppresses Cancer

Understanding the mechanistic basis by which exercise exerts anti-cancer effects has advanced substantially in recent years. Exercise engages multiple biological systems simultaneously, producing systemic changes in the endocrine, immune, metabolic, and vascular environments that are collectively hostile to tumor growth and progression.[28,29]

6.1 Exercise-Induced Myokines

Skeletal muscle functions as an endocrine organ, secreting a diverse array of bioactive peptides termed myokines during and after exercise.[28] The growing list of exercise-induced myokines—estimated to number over 600—includes interleukin-6 (IL-6), irisin, SPARC, oncostatin M, CXCL1, IL-10, IL-15, and CCL4, among others.[29] These molecules mediate crosstalk between skeletal muscle and distant organ systems including adipose tissue, liver, bone, and the tumor microenvironment.

Bettariga et al. (Breast Cancer Research and Treatment, 2025) demonstrated that a single bout of resistance training or high-intensity interval training (HIIT) in breast cancer survivors significantly elevated circulating concentrations of CXCL1, IL-10, and CCL4—myokines with established anti-tumor properties. Conditioned serum from exercising patients suppressed breast cancer cell viability and increased caspase-3/7 activity (a marker of apoptosis) in vitro.[31] These findings provide direct mechanistic evidence linking acute exercise to anti-cancer signaling.

SPARC (secreted protein acidic and rich in cysteine), irisin, and oncostatin M have each been shown in preclinical models to inhibit cancer cell proliferation, induce apoptosis, and directly modify the tumor immune microenvironment by promoting NK cell infiltration and reducing immunosuppressive regulatory T-cell populations.[29,34] Chen et al. (2025) further delineated the molecular pathways by which exercise regulates intratumoral angiogenesis, modulates adipokine signaling, and enhances antitumor immunity.[33]

6.2 Immune System Remodeling

Exercise training produces favorable adaptations in immune function that are particularly relevant to cancer biology. Acute exercise promotes mobilization and redistribution of NK cells, CD8+ cytotoxic T lymphocytes, and B cells into the circulation, increasing their capacity for tumor cell surveillance and cytolysis.[29] In exercising mice, NK cell accumulation within tumors has been directly associated with suppression of tumor growth, and this effect appears translatable to human cancers.[29] Zhang et al. (2025) confirmed in a comprehensive network meta-analysis that combined aerobic and resistance training produced superior improvements in both inflammatory biomarkers and NK cell function compared to unimodal exercise approaches.[32]

6.3 Metabolic and Hormonal Effects

Exercise exerts additional anti-cancer effects through systemic metabolic and hormonal mechanisms. Aerobic training reduces circulating insulin, insulin resistance, and IGF-1 levels—key drivers of proliferative signaling in multiple cancer subtypes including breast, colon, and endometrial cancers.[7] Exercise-mediated reduction in adiposity decreases the secretion of pro-inflammatory adipokines (leptin, IL-6, TNF-α) from visceral adipose tissue and normalizes sex hormone levels in postmenopausal women, reducing estrogen-mediated breast and endometrial cancer risk.[6,7] Furthermore, exercise accelerates intestinal transit time, reducing mucosal exposure to potential carcinogens in the colonic lumen.[7]

7. Summary of Key Evidence

Table 1 summarizes landmark studies and guidelines supporting exercise oncology across the cancer care continuum.

Table 1: Key Clinical Evidence in Exercise Oncology (2019–2026)

Study / Trial	Cancer Type	Intervention	Key Outcome
CHALLENGE Trial (Courneya et al., NEJM 2025)	Colon cancer (Stage II–III)	3-year structured aerobic exercise program post-adjuvant chemo (n=889, 55 centers)	28% reduction in recurrence risk (HR 0.72); 5-yr DFS 80.3% vs 73.9%; consistent OS benefit
Bettariga et al. (Breast Cancer Res Treat, 2025)	Breast cancer survivors	Single bout of RT or HIIT vs. control; myokine profiling	Increased anti-cancer myokines (CXCL1, IL-10, CCL4); suppressed BC cell growth in vitro
Soong et al. (JAMA Netw Open, 2025)	Mixed cancers (older adults)	Exercise interventions (aerobic/resistance/combined)	Significant reductions in depression, anxiety; improved QoL across cancer types
Zhang et al. (Support Care Cancer, 2025)	Cancer survivors (mixed)	Network meta-analysis of exercise modalities on inflammation/immune function	Combined exercise most effective for reducing inflammatory markers and enhancing NK cell activity
ACSM Moving Through Cancer Program (2025 edition)	All cancer types	Structured exercise referral pathways; Assess–Advise–Refer model	Evidence-based consensus: ≥150 min/week moderate exercise recommended for all survivors

Note: ACSM = American College of Sports Medicine; DFS = disease-free survival; HIIT = high-intensity interval training; NK = natural killer; RT = resistance training; BC = breast cancer; QoL = quality of life.

8. Exercise Prescription in Oncological Practice

Translating the evidence into clinical practice requires a structured, individualized approach to exercise prescription. The FITT principle (Frequency, Intensity, Type, Time) provides a practical framework, with cancer-specific modifications guided by the patient's treatment phase, comorbidities, functional capacity, and treatment-related toxicities.[13,14]

Table 2: FITT-Based Exercise Prescription Framework for Cancer Patients and Survivors

Parameter	Recommendation	Cancer-Specific Considerations
Frequency	3–5 days/week	Start with 2–3 days if deconditioned; avoid high-intensity on consecutive days during active treatment
Intensity	Moderate (RPE 12–14; 40–60% HRR)	Lower to light intensity (RPE 10–11) during cytotoxic chemotherapy; monitor for cardiotoxicity with anthracyclines
Type (Mode)	Aerobic + Resistance training (combined optimal)	Resistance training is key for preventing sarcopenic obesity; aquatic exercise for lymphedema; avoid contact sports with thrombocytopenia
Time (Duration)	150–300 min/week (moderate) or 75–150 min/week (vigorous)	Begin with 10–15 min sessions and progress; supervised sessions recommended especially in peri-treatment phase
Progression	Increase volume by ≤10% per week	Prehabilitation: maximize pre-surgery; peri-treatment: maintain; post-treatment: progress toward general population guidelines

Note: FITT = Frequency, Intensity, Type, Time; RPE = Rating of Perceived Exertion; HRR = Heart Rate Reserve.

8.1 The Assess–Advise–Refer Model

The ACSM has proposed a practical '3A' implementation framework for oncologists and primary care physicians: Assess patients' current physical activity levels and contraindications at every consultation; Advise all cancer patients and survivors to engage in regular physical activity and avoid prolonged sedentary behavior; and refer patients to qualified exercise oncology professionals, accredited exercise physiologists, or physiotherapists for individualized program design and supervision.[14,41]

8.2 Digital and Remote Delivery

Growing evidence supports the feasibility and effectiveness of digitally delivered exercise programs for cancer survivors who face barriers to in-person attendance, including travel distance, fatigue, and immunocompromised status. Smartphone applications, wearable activity trackers, and telehealth-supervised exercise sessions have demonstrated acceptable adherence and comparable outcomes to face-to-face programs in pilot cohort studies.[43] These modalities are particularly relevant for community clinics and primary care settings in resource-limited environments, including developing-country contexts.

9. Barriers to Implementation and Future Directions

Despite compelling evidence, the integration of exercise oncology into routine clinical practice remains suboptimal. Common barriers identified in the literature include: insufficient time and training among oncology clinicians to prescribe exercise; lack of reimbursement structures for exercise oncology services; patient-level barriers, including fatigue, pain, fear of injury, and lack of motivation; and limited access to qualified exercise professionals in community and rural settings.[41,42]

Future research priorities include:

- defining optimal exercise 'dose' for specific cancer types and molecular subtypes;
- elucidating the full myokine secretome and its tumor-regulatory implications; (3) integrating exercise biomarkers (e.g., circulating myokine panels) into personalized oncological care;
- conducting large-scale trials of exercise in additional cancer types beyond colon cancer; and
- developing scalable, technology-enabled exercise delivery models for resource-limited healthcare settings.[5,16,33]

The broader integration of exercise oncology within lifestyle medicine represents a paradigm shift from disease-focused treatment toward comprehensive, patient-centered care. Given the CHALLENGE Trial's landmark findings and accumulating mechanistic evidence, exercise should be considered a standard adjunct therapy in oncological care—with the same rigor afforded to pharmacological interventions.[11,12]

10. Conclusion

Exercise oncology has transitioned from an emerging field to an evidence-based therapeutic discipline within lifestyle medicine. Physical activity reduces the incidence of at least 13 cancer types, improves tolerance of active treatment, ameliorates cancer-related fatigue, depression, and cardiorespiratory deconditioning, and—as definitively demonstrated by the CHALLENGE Trial in 2025—reduces cancer recurrence and extends survival in colon cancer survivors. These effects are mediated by a complex interplay of myokine signaling, immune system remodeling, metabolic optimization, and anti-inflammatory adaptation.

Clinicians across oncology, primary care, and lifestyle medicine should adopt a proactive stance toward exercise as medicine. Using the Assess–Advise–Refer framework and FITT-based prescription principles, individualized exercise programs can be integrated at every phase of cancer care. As the global burden of cancer continues to rise and the survivor population expands, the systematic implementation of exercise oncology represents both a clinical imperative and a public health opportunity of profound importance.

Ethics Statement

Not applicable (narrative review of published literature).

Author Contributions

Phemyaphat Singto: Conceptualization, literature search, writing, and final approval of the manuscript.

Acknowledgement

Correspondence regarding this article should be addressed to Phemyaphat Singto, MD, Department of Medicine, Bangkok Hospital Pattaya, Pattaya, Chonburi, Thailand. Email: phemyaphat.s@gmail.com

Conflict of Interest Statement

The author declares no conflicts of interest.

About the Author

Phemyaphat Singto, MD, is a physician at Bangkok Hospital Pattaya, Chonburi, Thailand, with a clinical focus on lifestyle medicine. In her clinical practice, Dr. Singto integrates evidence-based lifestyle medicine principles into routine patient care, guiding individuals with cardiometabolic conditions, obesity, and cancer survivorship through structured behavior change programs. Dr. Singto maintains an active interest in translational research at the intersection of exercise science and oncology, contributing to the growing evidence base that supports physical activity as a therapeutic modality across the cancer care continuum. Her academic interests encompass exercise oncology, lifestyle medicine for chronic disease prevention, and the molecular mechanisms by which physical activity exerts systemic anti-inflammatory and anti-tumor effects.

References

1. World Health Organization. Global cancer statistics 2022. GLOBOCAN. Geneva: WHO; 2022. https://doi.org/10.3322/caac.21834
2. Siegel RL, Kratzer TB, Giaquinto AN, Sung H, Jemal A. Cancer statistics, 2025. CA Cancer J Clin. 2025;75(1):10-45. https://doi.org/10.3322/caac.21871
3. Guthold R, Stevens GA, Riley LM, Bull FC. Worldwide trends in insufficient physical activity from 2001 to 2016: a pooled analysis of 358 population-based data sources with 1.9 million participants. Lancet Glob Health. 2018;6(10):e1077-e1086. doi:10.1016/S2214-109X(18)30357-7. https://doi.org/10.1016/S2214-109X(18)30357-7
4. Lee IM, Shiroma EJ, Lobelo F, Puska P, Blair SN, Katzmarzyk PT; Lancet Physical Activity Series Working Group. Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life

expectancy. Lancet. 2012;380(9838):219-229. https://doi.org/10.1016/S0140-6736(12)61031-9

5. Hundal J, Peshin S, Ghazanfar R, Hayes S, Mansfield S, Sirotin N, et al. Implementing lifestyle medicine in cancer survivorship: a narrative review of global models. Am J Lifestyle Med. 2025. https://doi.org/10.1177/15598276251359525
6. Moore SC, Lee IM, Weiderpass E, et al. Association of leisure-time physical activity with risk of 26 types of cancer in 1.44 million adults. JAMA Intern Med. 2016;176(6):816-825. https://doi.org/10.1001/jamainternmed.2016.1548
7. Friedenreich CM, Ryder-Burbidge C, McNeil J. Physical activity, obesity and sedentary behavior in cancer etiology: epidemiology, biology and opportunities for prevention. Cancer Causes Control. 2021;32(8):803-816. https://doi.org/10.1002/1878-0261.12772
8. Patel AV, Friedenreich CM, Moore SC, et al. American Society of Clinical Oncology statement on exercise and cancer prevention and treatment. J Clin Oncol. 2019;37(10):876-882. doi:10.1200/JCO.18.02323.
9. Biswas A, Oh PI, Faulkner GE, et al. Sedentary time and its association with risk for disease incidence, mortality, and hospitalization in adults: a systematic review and meta-analysis. Ann Intern Med. 2015;162(2):123-132. https://doi.org/10.7326/m14-1651
10. Ligibel JA, Bohlke K, May AM, et al. Exercise, diet, and weight management during cancer treatment: ASCO guideline. J Clin Oncol. 2022;40(22):2491-2507. https://doi.org/10.1200/JCO.22.00687
11. Courneya KS, Booth CM, Gill S, et al. Structured exercise after adjuvant chemotherapy for colon cancer: the CHALLENGE randomized controlled trial. N Engl J Med. 2025;393(1):13-25. https://doi.org/10.1056/nejmoa2502760
12. ASCO. Movement is medicine: structured exercise program may lower risk of cancer recurrence and death for some colon cancer survivors. ASCO News Release. 2025 Jun 1. https://www.asco.org/about-asco/press-center/news-releases/movement-medicine-structured-exercise-program-challenge.
13. Schmitz KH, Courneya KS, Matthews C, et al.; American College of Sports Medicine. American College of Sports Medicine roundtable on exercise guidelines for cancer survivors. Med Sci Sports Exerc. 2010;42(7):1409-1426. https://doi.org/10.1249/mss.0b013e3181e0c112
14. Campbell KL, Winters-Stone KM, Wiskemann J, et al. Exercise guidelines for cancer survivors: consensus statement from international multidisciplinary roundtable. Med Sci Sports Exerc. 2019;51(11):2375-2390. https://doi.org/10.1249/mss.0000000000002116
15. Soong RY, Low CE, Ong V, et al. Exercise interventions for depression, anxiety, and quality of life in older adults with cancer: a systematic review and meta-analysis. JAMA Netw Open. 2025;8(2):e2457859. https://doi.org/10.1001/jamanetworkopen.2024.57859

16. Brown JC, Ligibel JA. Exercise medicine for cancer survivors. Ann Intern Med. 2024;177(3):374-382. doi:10.7326/M23-1579.
17. Toohey K, Pumpa KL, Arnolda L, et al. A pilot study examining the effects of low-volume high-intensity interval training and continuous low to moderate intensity training on quality of life, functional capacity and cardiovascular risk factors in cancer survivors. PeerJ. 2016;4:e1613. https://doi.org/10.7717/peerj.2613
18. Patsou ED, Alexias GD, Anagnostopoulos FG, Karamouzis MV. Effects of physical exercise on depressive symptoms during breast cancer treatment: a meta-analysis of randomised control trials. ESMO Open. 2017;2(6):e000interruption. https://doi.org/10.1136/esmoopen-2017-000271
19. Christensen JF, Simonsen C, Hojman P. Exercise training in cancer control and treatment. Compr Physiol. 2019;9(1):165-205. https://doi.org/10.1002/cphy.c180016
20. Demark-Wahnefried W, Colditz GA, Rock CL, et al. Quality of life outcomes from the Exercise and Nutrition Enhance Recovery and Good Health for You (ENERGY) randomized controlled trial. J Clin Oncol. 2015;33(12):1340-1346. https://doi.org/10.1007/s10549-015-3627-5
21. Stout NL, Baima J, Swisher AK, Winters-Stone KM, Welsh J. A systematic review of exercise systematic reviews in the cancer literature (2005-2017). PM R. 2017;9(9S2):S347-S384. https://doi.org/10.1016/j.pmrj.2017.07.074
22. NCCN. NCCN guidelines insights: survivorship, version 2.2025. J Natl Compr Canc Netw. 2025;23(6):208-217. https://doi.org/10.6004/jnccn.2024.0062
23. Carli F, Silver JK, Feldman LS, et al. Surgical prehabilitation in patients with cancer: state-of-the-science and recommendations for future research from a panel of subject matter experts. Phys Med Rehabil Clin N Am. 2017;28(1):49-64. https://doi.org/10.1016/j.pmr.2016.09.002
24. Carretti G, Tognaccini A, et al. Kinesiological insights into exercise prescription within oncological prehabilitation: current knowledge and future perspectives. Front Sports Act Living. 2025;7:1715484. https://doi.org/10.3389/fspor.2025.1715484
25. Santa Mina D, Clarke H, Ritvo P, et al. Effect of total-body prehabilitation on postoperative outcomes: a systematic review and meta-analysis. Physiotherapy. 2014;100(3):196-207. https://doi.org/10.1016/j.physio.2013.08.008
26. Minnella EM, Awasthi R, Loiselle SE, Agnihotram RV, Ferri LE, Carli F. Effect of exercise and nutrition prehabilitation on functional capacity in esophagogastric cancer surgery: a randomized clinical trial. JAMA Surg. 2018;153(12):1081-1089. https://doi.org/10.1001/jamasurg.2018.1645
27. Pedersen BK, Febbraio MA. Muscles, exercise and obesity: skeletal muscle as a secretory organ. Nat Rev Endocrinol. 2012;8(8):457-465. https://doi.org/10.1038/nrendo.2012.49
28. Hojman P, Gehl J, Christensen JF, Pedersen BK. Molecular mechanisms linking exercise to cancer prevention and treatment. Cell Metab. 2018;27(1):10-21. https://doi.org/10.1016/j.cmet.2017.09.015

29. Bettariga F, Taaffe DR, Crespo-Garcia C, et al. A single bout of resistance or high-intensity interval training increases anti-cancer myokines and suppresses cancer cell growth in vitro in survivors of breast cancer. Breast Cancer Res Treat. 2025;213:171-180. https://doi.org/10.1007/s10549-025-07772-w
30. Zhang XN, Liang ZD, Li MD. Comparison of different exercise modalities on chronic inflammation and immune function in cancer survivors: a systematic review with network, dose-response, and Bayesian meta-analyses. Support Care Cancer. 2025;33(12):1158. https://doi.org/10.1007/s00520-025-09971-z
31. Chen J, Li Y, Wang L, Liu Q. The molecular mechanisms of exercise in cancer prevention and management. Eur J Cancer Prev. 2025. https://doi.org/10.1097/cej.0000000000000989
32. Corrêa R, de Almeida CV, da Fonseca V, Tabak BM. Influence of physical exercise on health improvement in older adult cancer patients: a systematic review. Front Public Health. 2025;13:1525021. https://doi.org/10.3389/fpubh.2025.1525021
33. Gannon NP, Vaughan RA, Garcia-Smith R, Bisoffi M, Trujillo KA. Effects of the exercise-inducible myokine irisin on malignant and non-malignant breast epithelial cell behavior in vitro. Int J Cancer. 2015;136(4):E197-E202. https://doi.org/10.1002/ijc.29142
34. Bettariga F, Galvao DA, Taaffe DR, et al. Association of muscle strength and cardiorespiratory fitness with all-cause and cancer-specific mortality in patients diagnosed with cancer: a systematic review with meta-analysis. Br J Sports Med. 2025;59:722-732. https://doi.org/10.1136/bjsports-2024-108671
35. Whellan DJ, O'Connor CM, Lee KL, et al. Heart failure and a controlled trial investigating outcomes of exercise training (HF-ACTION): design and rationale. Am Heart J. 2007;153(2):201-211. https://doi.org/10.1016/j.ahj.2006.11.007
36. Scott JM, Zabor EC, Schwitzer E, et al. Efficacy of exercise therapy on cardiorespiratory fitness in patients with cancer: a systematic review and meta-analysis. J Clin Oncol. 2018;36(22):2297-2305. https://doi.org/10.1200/jco.2017.77.5809
37. Schmitt J, Lindner N, Reuss-Borst M, Holmberg HC, Sperlich B. A 3-week multimodal intervention involving high-intensity interval training in female cancer survivors: a randomized controlled trial. Physiol Rep. 2016;4(3):e12693. https://doi.org/10.14814/phy2.12693
38. Awick EA, Phillips SM, Lloyd GR, McAuley E. Physical activity, self-efficacy and self-esteem in breast cancer survivors: a panel model. Psychooncology. 2017;26(10):1625-1631. https://doi.org/10.1002/pon.4180
39. Watson G, Coyne Z, Houlihan E, Leonard G. Exercise oncology: an emerging discipline in the cancer care continuum. Postgrad Med. 2022;134(1):26-36. https://doi.org/10.1080/00325481.2021.2009683
40. Blaney JM, Lowe-Strong A, Rankin-Watt J, Campbell A, Gracey JH. Cancer survivors' exercise barriers, facilitators and preferences in the context of fatigue, quality of

life and physical activity participation: a questionnaire-survey. Psychooncology. 2013;22(1):186-194. https://doi.org/10.1002/pon.2072

41. Zhang F, Bang D, Visperas CA, Tun MH, Tay SS. Feasibility, user acceptance, and outcomes of using a cancer prehabilitation app for exercise: pilot cohort study. JMIR Form Res. 2025;9:e64427. https://doi.org/10.2196/64427
42. Phillips SM, Awick EA, Conroy DE, Pellegrini CA, Mailey EL, McAuley E. Objectively measured physical activity and sedentary behavior and quality of life indicators in survivors of breast cancer. Cancer. 2015;121(22):4044-4052. https://doi.org/10.1002/cncr.29620
43. Humpel N, Iverson DC. Review and critique of the quality of exercise recommendations for cancer patients and survivors. Support Care Cancer. 2005;13(7):493-502. https://doi.org/10.1007/s00520-005-0811-x
44. Bower JE. Cancer-related fatigue–mechanisms, risk factors, and treatments. Nat Rev Clin Oncol. 2014;11(10):597-609. https://doi.org/10.1038/nrclinonc.2014.127
45. Mustian KM, Alfano CM, Heckler C, et al. Comparison of pharmaceutical, psychological, and exercise treatments for cancer-related fatigue: a meta-analysis. JAMA Oncol. 2017;3(7):961-968. https://doi.org/10.1001/jamaoncol.2016.6914
46. Lahart IM, Metsios GS, Nevill AM, Carmichael AR. Physical activity for women with breast cancer after adjuvant therapy. Cochrane Database Syst Rev. 2018;1(1):CD011292. https://doi.org/10.1002/14651858.cd011292.pub2
47. Mishra SI, Scherer RW, Snyder C, Geigle P, Gotay C. Are exercise programs effective for improving health-related quality of life among cancer survivors? A systematic review and meta-analysis. Oncol Nurs Forum. 2014;41(6):E326-E342. https://doi.org/10.1188/14.onf.e326-e342
48. Dieli-Conwright CM, Courneya KS, Demark-Wahnefried W, et al. Aerobic and resistance exercise improves physical fitness, bone health, and quality of life in overweight and obese breast cancer survivors: a randomized controlled trial. Breast Cancer Res. 2018;20(1):124. https://doi.org/10.1186/s13058-018-1051-6