Impact of exercise on health outcomes in people with cancer: an umbrella review of systematic reviews and meta-analyses of randomised controlled trials

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ABSTRACT

Objective To examine the comprehensive health impacts of exercise on people with cancer by systematically summarising existing evidence and assessing the strength and reliability of the associations.
Design Umbrella review of meta-analyses.
Data source PubMed, Embase, Cochrane and Web of Science databases were searched from their inception to 23 July 2024.
Eligibility criteria for selecting studies Meta-analyses of randomised controlled trials that investigated the associations between exercise and health outcomes among people with cancer.
Results This umbrella review identified 485 associations from 80 articles, all evaluated as moderate to high quality using A Measurement Tool to Assess Systematic Reviews (AMSTAR). Two hundred and sixty (53.6%) associations were statistically significant ($p<0.05$), 81/485 (16.7%) were supported by high-certainty evidence according to the Grading of Recommendations Assessment, Development, and Evaluation criteria. Compared with usual care or no exercise, moderate- to high-certainty evidence supported the view that exercise significantly mitigates adverse events associated with cancer and its treatments (eg, cardiac toxicity, chemotherapy-induced peripheral neuropathy, cognitive impairment and dyspnoea). Exercise also modulates body composition and biomarkers (eg, insulin, insulin-like growth factor-1, insulin-like growth factor-binding protein-1 and C-reactive protein) in people with cancer, and enhances sleep quality, psychological well-being, physiological functioning and social interaction, while improving overall quality of life.
Conclusion Exercise reduces adverse events and enhances well-being through a range of health outcomes in people with cancer.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Exercise not only mitigates the risk of various types of cancer but also prevents adverse health outcomes in people with cancer and reduces overall mortality rates.
⇒ A gap exists in summarising the comprehensive, evidence-based impact of exercise on health outcomes among people with cancer.
⇒ Current guidelines advocate that individuals with cancer participate in both aerobic and resistance exercises.

WHAT THIS STUDY ADDS

⇒ This umbrella review suggests that exercise enhances a range of health outcomes in people with cancer.
⇒ Exercise mitigates adverse outcomes associated with cancer and its treatments, such as cardiac toxicity, chemotherapy-induced peripheral neuropathy symptoms, cognitive impairment and dyspnoea.
⇒ Moderate- to high-certainty evidence also supports the view that exercise enhances psychological well-being and quality of life in people with cancer.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ This study reinforces the efficacy of incorporating exercise into cancer treatment protocols.

INTRODUCTION

Cancer represents a major societal, public health and economic challenge in the 21st century,[1 2] significantly affecting physical and mental health. Compared with those without cancer, people often experience persistent symptoms, treatment-related side effects, reduced quality of life (QoL), and increased risks of recurrence and mortality. Identifying modifiable lifestyle factors, such as physical activity, is crucial for evidence-based recommendations.[3]

Exercise, a structured and systematic form of physical activity,[4] is deemed safe and recommended for all individuals with cancer to 'avoid inactivity.'[5 6] The American Society of Clinical Oncology recommends that individuals with cancer incorporate regular aerobic exercises (AE) and resistance exercises (RE) into their regimen during active treatment,[7] with similar guidelines adopted globally.[8–10] Beyond aerobic and resistance training, mind–body exercises, such as Tai Chi, Qigong and yoga, are cost-effective, accessible and can be practised at home.[11–13] These exercises integrate mental focus, physical movement and breath control, helping to reduce stress, improve sleep, physical function and

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quality of life (QoL).[14–17] Growing research highlights their positive impact on cancer prognosis.[14 16–18]

Numerous meta-analyses have evaluated the impact of exercise on health outcomes in patients with cancer, but significant gaps remain.[19–21] For example, a secondary analysis of randomised controlled trials (RCTs) revealed that a 6-month AE intervention significantly alleviated self-reported symptoms of chemotherapy-induced peripheral neuropathy (CIPN) in ovarian cancer[22]; however, another meta-analysis found no evidence.[23] Debate continues over the effects of exercise on cognitive function,[24 25] cardiotoxicity,[26 27] and circulating biomarkers, such as adiponectin,[28 29] C-reactive protein (CRP),[30 31] insulin,[29] and insulin-like growth factor (IGF).[32 33] Moreover, the International Agency for Research on Cancer has assessed physical activity evidence only for survivors from breast and colorectal cancer (CRC), with limited data from RCTs.[34]

An umbrella review (UR) is a high-level methodology in evidence-based medicine that integrates and synthesises meta-analyses to provide a comprehensive overview of high-quality research on a specific subject.[35–37] Currently, no UR has comprehensively evaluated meta-analysis evidence on exercise and health outcomes in patients with cancer. To address this gap, we conducted an UR of RCT-based meta-analyses to investigate the associations between exercise and overall health outcomes in patients with cancer, aiming to provide robust evidence supporting the clinical application of exercise in cancer care.

METHODS

Protocol registration

The UR adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis guidelines.[38] Furthermore, the UR was officially registered in PROSPERO (CRD42024572146).

Search strategy

To identify systematic reviews and meta-analyses of RCTs on the association between exercise and multiple health outcomes among individuals with cancer, two investigators independently conducted a comprehensive search in PubMed, Embase, Cochrane and Web of Science databases from inception to 23 July 2024. Additionally, the references of eligible articles were manually scrutinised. The detailed search strategy is displayed in online supplemental table 1.

Eligibility criteria

Two reviewers independently screened titles, abstracts, and full texts to ensure compliance with the inclusion criteria. Any differences were addressed by a third reviewer. Studies were selected based on the PICOS (Population, Intervention, Comparison, Outcome, Study design) framework (figure 1), and details can be found in online supplemental table 2.

Data extraction

Eight trained investigators worked in pairs to independently extract information from each eligible study. Any disparities were adjudicated by a senior investigator. Extracted details included the first author, year of publication, study design, number of cases, total population, intervention, comparison, health outcomes, mean (SD) and effect sizes with 95% CIs.

Assessment of methodological quality

The quality of systematic reviews and meta-analyses was evaluated using the MeaSurement Tool to Assess systematic Reviews (AMSTAR) checklist, with 1 point awarded for each 'yes' answer (out of 11 items).[39] The AMSTAR score was classified as high (8–11), moderate (4–7) and low (0–3).[40 41] Three investigators independently assessed the quality of the reviews, with discrepancies resolved by a senior investigator.

Evaluation of certainty of evidence

Using the Grading of Recommendations, Assessment, Development and Evaluations (GRADE), 12 trained investigators independently assessed the certainty of evidence as high, moderate, low or very low.[42] Evidence from RCTs begins as high certainty but can be downgraded based on criteria, including risk of bias, indirectness, inconsistency, imprecision and publication bias.[42 43]

Data analysis

We categorised effect sizes by intervention, comparator, population and outcomes to get a list of unique associations. Using a random-effects model, we recalculated the pooled effect size with 95% CI for associations identified in eligible meta-analyses.[44 45] A P value <0.05 was deemed statistically significant. Heterogeneity was evaluated using the I^2 statistic. Values exceeding 50% indicated moderate heterogeneity, and values surpassing 75% suggest large heterogeneity.[46] We interpreted the standardised mean difference (SMD) analysis using Cohen's

Inclusion criteria	Exclusion criteria
Population-all individuals diagnosed with cancer	***Analytical method***-systematic reviews without quantitative analysis
Intervention-exercise (e.g., Aerobic exercise training, Resistance exercise, Qigong, Tai Chi, high-intensity interval training, yoga, etc.). No specific limitations were imposed on the type, length, frequency, or duration of exercise. Co-interventions were allowed	***Study quantity***-systematic reviews with meta-analyses that included fewer than three primary studies
Comparison-usual care, or mix (a combination of usual care with any other active treatment)	***Data integrity***-systematic reviews with meta-analyses that did not provide a relevant exposure or specific data for re-analysis (e.g., standardized mean difference, mean difference, 95% confidence intervals and the number of participants)
Outcomes-four major categories of health outcomes were encompassed: (1) adverse effects of cancer and its treatment; (2) body composition, body mass index, biomarkers; (3) sleep quality, quality of life and psychological outcomes; (4) physiological and social function;	***Language***-studies published in non-English
Study design-systematic reviews and meta-analyses of randomized controlled trials that provided specific data for reanalysis, including effect sizes with 95% confidence intervals, the number of cases, and the total population	***Study design***-conducting systematic reviews and meta-analyses of trials that are not randomized controlled trials, animal studies, genetic polymorphisms, conference abstracts, and laboratory research

Figure 1 The list of inclusion and exclusion criteria of the umbrella review.

d effect size criteria: a value of 0.2 indicates a small effect, 0.5 indicates a medium effect and 0.8 indicates a large effect.[47]

We conducted sensitivity analyses for significant associations with moderate-to-high certainty, excluding studies with small sample sizes (25th percentile) or high risk of bias (based on quality assessments). If no quality assessment was available or lacked specific methods and scores, we re-evaluated the primary studies included in the meta-analysis using Cochrane criteria.[48–50] Additionally, we assessed the certainty of evidence from the meta-analyses excluded owing to overlapping data, ensuring whether their results aligned with main analysis. All statistical analyses were conducted using STATA version 17.

Equity, diversity and inclusion statement

Our study examined the impact of exercise on health outcomes among individuals with cancer, across all genders, socioeconomic levels and marginalised communities. The author team, comprising 13 women and 7 men from various disciplines (obstetrics, gynaecology, epidemiology, clinical research, cardiology, and clinical laboratories), included scholars at different stages of their careers. Data collection followed a standardised method, ensuring research integrity across diverse cancer populations. Our methodology remained consistent, regardless of regional, educational or socioeconomic differences.

RESULTS

Literature review

We identified 3070 records from four databases. After removing duplicates and screening, 80 studies with 485 associations were included in our UR (figure 2). The excluded records during the process of full-text screening are listed in online supplemental table 3.

Characteristics of included meta-analyses and associations

A total of 485 associations published between 2012 and 2024 are shown in online supplemental tables 4 and 5. Among these associations, the types of exercise included mind–body exercise (138, 28.5%), AE and RE (48, 9.9%), high-intensity interval training (HIIT) (18, 3.7%) and other exercises (281, 57.9%). Additionally, these associations were explored in people diagnosed with various types of cancer, including breast (244, 50.3%), digestive system (20, 4.1%), haematological malignancies (13, 2.7%), lung (47, 9.7%), prostate (12, 2.5%) and others (149, 30.7%).

Based on the random-effects model, 260 (53.6%) and 87 (17.9%) associations respectively reached statistical significance at $p<0.05$ and $p<10^{-3}$. Additionally, 267 (55.1%), 95 (19.6%) and 123 (25.4%) associations showed low, moderate, and high heterogeneity, respectively (online supplemental table 5).

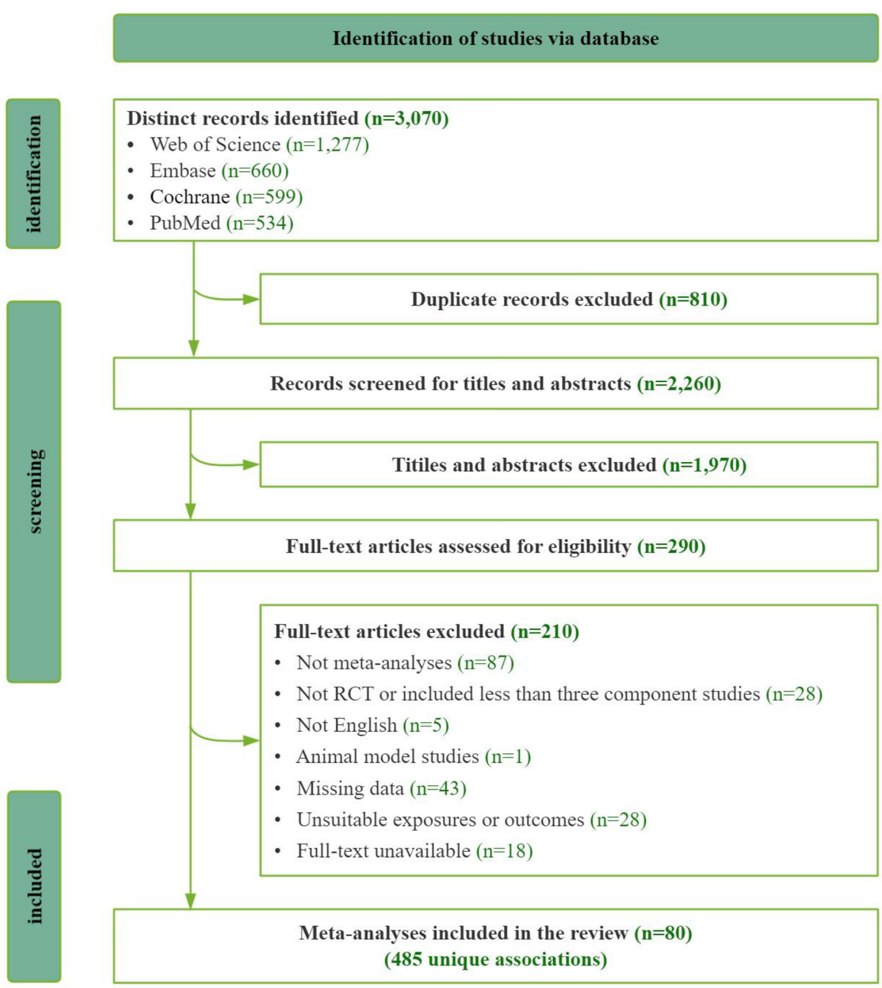

Figure 2 Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram of selection of included meta-analyses in the umbrella review. RCT, randomised controlled trial.

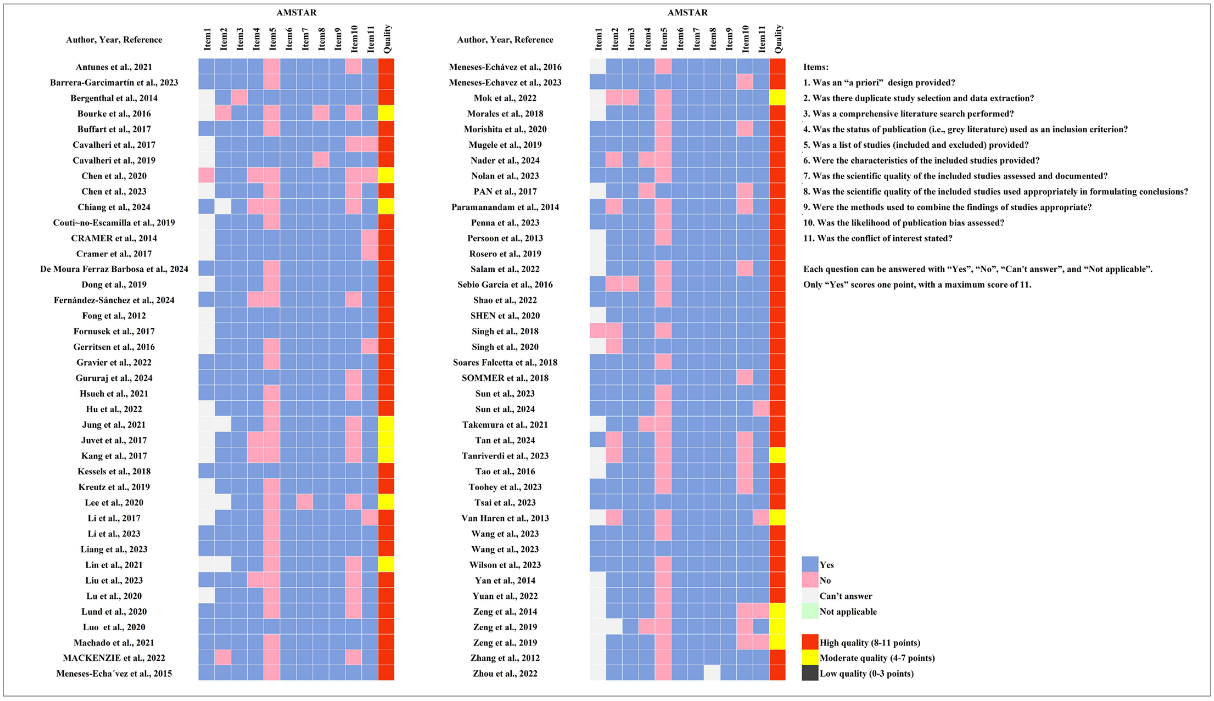

Figure 3 Methodological quality assessment of the included articles using A MeaSurement Tool to Assess systematic Reviews (AMSTAR).

Assessment of the methodological quality and evidence certainty

According to the AMSTAR, 66 (82.5%) and 14 (17.5%) of 80 analyses were deemed to be of high and moderate quality, respectively (figure 3).

Approximately 81 (16.7%) and 152 (31.3%) of the meta-analyses remained high and moderate certainty, respectively. Additionally, the remaining 177 (36.5%) and 75 (15.5%) associations were classified as having low or very low certainty, respectively (online supplemental table 6).

Adverse effects of cancer and its treatment

We summarised 55 (11.3%) associations between exercise and cancer-related adverse reactions and prognosis among people with cancer, which had adverse effects (eg, CIPN, cardiac toxicity, etc; 31/485, 6.4%) and prognosis (eg, mortality, postoperative complications, etc; 24/485, 4.9%). Nine (1.9%) or 485 associations exhibited high certainty, while 16 (3.3%) demonstrated moderate certainty (online supplemental figure 1a).

Cancer-related cognitive impairment, cardiac toxicity, CIPN and gastrointestinal symptoms

One case of high-certainty evidence demonstrated that exercise improved cancer-related cognitive impairment in people (≥18 years) with cancer (SMD=0.27, 95% CI 0.20 to 0.35).[51] Additionally, moderate-certainty evidence supported the view that mind–body exercise improved cognitive function in people with lung cancer (SMD=1.09, 95% CI 0.47 to 1.71).[16] In the context of cardiac toxicity, moderate-certainty evidence supported the view that combined training enhanced left ventricular ejection fraction (LVEF) in women with breast cancer (BC) (SMD=1.45, 95% CI 0.84 to 2.06).[52] Furthermore, moderate-certainty evidence indicated that overall exercise interventions effectively alleviated the symptoms of CIPN in people with cancer who were undergoing, or had completed, chemotherapy (SMD=−0.53, 95% CI −0.83 to –0.23).[53] For gastrointestinal symptoms, moderate-certainty evidence highlighted the effectiveness of yoga in alleviating symptoms in women with BC (SMD=−0.39, 95% CI −0.54 to –0.25).[54]

Length of stay in the hospital, postoperative complications and mortality

High-certainty evidence indicated that preoperative AE combined with other forms of exercise reduced the risk of postoperative pulmonary complications (RR=0.50, 95% CI 0.38 to 0.66) among people with non-small-cell lung cancer.[55] Moderate-certainty evidence supported the view that preoperative exercise shortened postoperative hospital stays (mean difference (MD)=−2.29, 95% CI −3.59 to –0.99), reduced the risk of clinically relevant postoperative complications (RR=0.42, 95% CI 0.25 to 0.69) and reduced dyspnoea (SMD=−0.45, 95% CI −0.78 to –0.12) in this population.[55 56] Furthermore, exercise improved dyspnoea in people with advanced-stage cancer (SMD=−0.18, 95% CI −0.36 to 0.00),[57] as supported by moderate-certainty evidence. Additionally, moderate-certainty evidence demonstrated a significant association between exercise and reduced mortality among people with cancer (risk ratio (RR)=0.76, 95% CI 0.62 to 0.93).[58]

Body composition, BMI, biomarkers

We found 67 (13.8%) associations between exercise and body and strength assessment, including body mass index (BMI) (7/485, 1.4%), body composition (25, 5.2%) and biomarkers (35, 7.2%); 12 (2.5%) and 18 (3.7%) associations showed high and moderate certainty, respectively (online supplemental figure 1b).

BMI

Two analyses with high-certainty evidence demonstrated that exercise increased BMI among women with stage II+ BC (SMD=0.17, 95% CI 0.02 to 0.33), but decreased BMI among people with cancer who had completed their main treatment (MD=−0.62, 95% CI −1.19 to –0.06).[20 59]

Body fat

Exercise was associated with a reduced fat percentage in people with early-stage BC (MD=−1.46, 95% CI −1.95 to –0.98), increased lean body mass in people with prostate cancer (MD=0.88, 95% CI 0.40 to 1.36) and reduced body fat rate and body fat mass ($MD_{body\ fat\ rate}$=−0.93, 95% CI −1.39 to –0.47; $MD_{body\ fat\ mass}$=−0.60, 95% CI −1.10 to –0.10) in people with prostate cancer.[60 61] These above associations were graded as moderate-certainty evidence.

Biomarkers

One high-certainty association supported the view that a combination of AE and RE was effective in reducing serum insulin (SMD=−0.49, 95% CI −0.94 to –0.05).[62] Three moderate-certainty associations indicated that AE, RE, and mind–body exercises reduced serum concentrations of IGF-1 (weighted mean difference=−19.95, 95% CI −22.67 to –17.23),[63] IGFBP-1 (IGF binding protein-1) (SMD=−0.35, 95% CI −0.67 to –0.04)[64] and CRP levels (SMD=−0.49, 95% CI −0.93 to –0.04)[62] in women with BC.

Sleep quality, QoL and psychological outcomes

A total of 172 (35.5%) associations were summarised, including anxiety (21/485, 4.3%), depression (28, 5.8%), sleep problems (47, 9.7%), QoL (63, 13.0%) and other emotional status (13, 2.7%); 32 (6.6%) and 45 (9.3%) associations showed high and moderate certainty, respectively (online supplemental figure 1c).

Sleep problems

Notably, six associations with high certainty supported the view that yoga reduced short-term sleep disturbance in women with BC (SMD=−0.26, 95% CI −0.45 to –0.06).[65] Additionally, two analyses with high-certainty evidence indicated that exercise alleviated insomnia in people with advanced-stage cancer (SMD=−0.36, 95% CI −0.56 to –0.17),[57] combined training mitigated the decline in sleep quality among people with cancer (SMD=−0.25, 95% CI −0.43 to –0.06).[66] Furthermore, exercise during and after treatment decreased the Pittsburgh Sleep Quality Index score (SMD=−0.28, 95% CI −0.44 to –0.11), and reduced self-reported sleep problems (SMD=−0.32, 95% CI −0.54 to –0.10).[67]

QoL

Yoga improved the short-term, health-related QoL (HRQoL) of people with BC (SMD=0.24, 95% CI 0.04 to 0.45).[65] Exercise improved thhe physical HRQoL of people with lung cancer (SMD=0.69, 95% CI 0.47 to 0.90),[68] as well as the overall QoL of older people with CRC undergoing chemotherapy (SMD=0.23, 95% CI 0.02 to 0.44)[69] and people with BC (SMD=0.88, 95% CI 0.40 to 1.36).[70] All these four associations reached high certainty.

Anxiety

One analysis with high-certainty evidence showed that Qigong and Tai Chi relieved anxiety in people (≥18 years) with cancer (SMD=0.29, 95% CI 0.18 to 0.40).[71] Additionally, moderate-certainty evidence showed that yoga reduced anxiety in women with BC (SMD=−0.98, 95% CI −1.39 to –0.57).[54]

Depression

Post-diagnosis exercise (SMD=−0.24, 95% CI −0.42 to –0.05), post-radiotherapy exercise (SMD=−0.50, 95% CI −0.97 to –0.04) and exercise combined with yoga or spiritual growth (SMD=−0.38, 95% CI −0.62 to –0.13) were linked to decreased depression among women with BC,[72–74] supported by moderate-certainty evidence.

Other emotional status

High-certainty evidence from one analysis demonstrated that exercise enhanced the psychological well-being of elderly people with CRC undergoing chemotherapy (SMD=0.29, 95% CI 0.16 to 0.41).[69]

Physiological and social function

There were 191 (39.4%) associations evaluating exercise and pain (10/485, 2.1%), physical health (10, 2.1%), social function (15, 3.1%), muscular strength (15, 3.1%), fatigue (66, 13.6%) and physical function (75, 15.5%); 28/485 (5.8%) and 73 (15.1%) associations exhibited high and moderate certainty, respectively (online supplemental figure 1d).

Physical function

Preoperative AE combined with other forms of exercise improved the 6-minute walk test in people with non-small-cell lung cancer (SMD=0.27, 95% CI 0.10 to 0.44), indicating an effect size between small and moderate.[55] Additionally, exercise during or after chemotherapy enhanced peak oxygen uptake ($VO2_{peak}$) in people with cancer (MD=2.46, 95% CI 1.44 to 3.47),[75] where the upper limit exceeds the minimal clinically important difference value of 2.5. AE, RE and supervised exercise improved physical function in women with BC (SMD=0.19, 95% CI 0.05 to 0.33), indicating a small effect size.[76] HIIT improved aerobic fitness (SMD=0.54, 95% CI 0.37 to 0.71) of people (≥18 years) with cancer, indicating an effect size between moderate and large.[77] All associations were supported by high-certainty evidence (figure 4).

Physical health

Short-term exercise (AE and/or RE) improved physical and general health in people with digestive cancer ($SMD_{physical}$=0.22, 95% CI 0.00 to 0.45; $SMD_{general}$=0.34, 95% CI 0.04 to 0.63),[78] supported by high-certainty evidence. Two analyses of moderate-certainty evidence supported the view that weight-training exercise improved the physical health score of women with BC-related lymphoedema (SMD=0.34, 95% CI 0.09 to 0.58),[79] and exercise enhanced physical fitness in people with CRC (SMD=0.59, 95% CI 0.25 to 0.93).[80]

Muscular strength

Three associations with high-certainty evidence supported the view that among women with BC, weight training exercise improved arm strength (SMD=0.30, 95% CI 0.14 to 0.46),[81] chest press (SMD=0.91, 95% CI 0.74 to 1.08) and leg press (SMD=0.70, 95% CI 0.48 to 0.92).[79] Moderate-certainty evidence indicated that Tai Chi enhanced arm strength in women with BC within 12 weeks (SMD=0.44, 95% CI 0.20 to 0.68),[81] and that exercise during and after treatment enhanced upper body strength in women with stage II+ BC (SMD=0.43, 95% CI 0.17 to 0.69).[59]

Outcomes[references]	Intervention	Type of effect metric	Random effects (95% CI)	Random effects (95% CI)	MCID
Physiological and Social Function					
Physical function					
Aerobic fitness [32]	Exercise (during and after treatment)	SMD		0.50 (0.24, 0.76)	2.50
Aerobic fitness (cancer type subgroup) [1]	HIIT	SMD		0.54 (0.37, 0.71)	2.50
Aerobic fitness (treatment status subgroup) [1]	HIIT	SMD		0.54 (0.33, 0.75)	2.50
Cardiorespiratory fitness [20]	Aerobic Exercise	SMD		1.56 (0.72, 2.39)	2.50
Exercise capacity [50]	Exercise	SMD		0.37 (0.07, 0.67)	-
Functional capacity (6MWD) [16]	Preoperative aerobic combined with other forms of exercise	SMD		0.27 (0.10, 0.44)	20.00
Physical activity (≥ 6 months post-intervention) [48]	Exercise	SMD		0.30 (0.09, 0.51)	-
Physical condition [11]	Mind-body exercise	SMD		0.92 (0.42, 1.43)	-
Physical function [75]	Aerobic Exercise	SMD		0.17 (0.06, 0.28)	0.39
Physical function [75]	Aerobic, resistance, mix exercise	SMD		0.19 (0.05, 0.33)	0.39
Physical function [59]	Supervised exercise	β		1.24 (1.17, 1.31)	0.39
Physical function [59]	AE or RE or AE and RE	β		1.20 (1.14, 1.27)	0.39
Physical function [75]	Mix exercise	SMD		0.59 (0.12, 1.07)	0.39
Physical function [3]	Exercise	SMD		0.24 (0.03, 0.44)	0.39
Physical function [75]	Exercise (during treatment)	SMD		0.14 (0.01, 0.27)	0.39
Physical function [47]	Post-diagnosis exercise	SMD		0.36 (0.03, 0.70)	0.39
Physical function [75]	Exercise (after treatment)	SMD		0.41 (0.19, 0.63)	0.39
Physical function [75]	Exercise (during or after treatment)	SMD		0.27 (0.13, 0.42)	0.39
Physical function [75]	Aerobic exercise+Resistance exercise	SMD		0.27 (0.13, 0.42)	0.39
Physical function [75]	Aerobic, mix exercise	SMD		-0.32 (-0.49, -0.14)	0.39
$VO2_{peak}$ L/min [34]	Exercise (during or postchemotherap)	MD		0.18 (0.07, 0.28)	0.03
$VO2_{peak}$ mL/kg/min [34]	Exercise (during or postchemotherap)	MD		2.46 (1.44, 3.47)	2.50
$VO2_{peak}$ mL/kg/min [34]	Exercise (during chemotherap)	MD		2.69 (0.97, 4.42)	2.50
$VO2_{peak}$ mL/kg/min [34]	Exercise (postchemotherap)	MD		2.33 (1.05, 3.61)	2.50

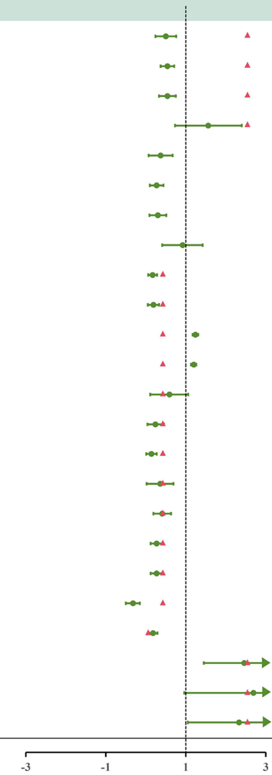

Figure 4 Forest plot of the impact of exercise on physical function in people with cancer and the minimum clinically important difference. AE, aerobic exercise; HIIT, high-intensity interval training; MCID, minimal clinically important difference; QoL, quality of life; RE, resistance exercise; VO_2peak, peak of oxygen consumption; 6MWD, 6-minute walk distance, β, regression coefficients.

Fatigue and pain

Two analyses with high-certainty evidence demonstrated that combined HIIT programmes (SMD=0.66, 95% CI 0.42 to 0.89),[82] and walking combined with RE (SMD=−0.37, 95% CI −0.57 to −0.17),[83] significantly improved cancer-related fatigue in individuals with cancer. Additionally, RE alone has been shown to effectively reduce general fatigue in women with BC (SMD=−0.28, 95% CI −0.48 to −0.08)[84] and among people undergoing cytotoxic treatment for cancer (SMD=−0.32, 95% CI −0.47 to −0.16).[85] For pain management, two analyses with moderate-certainty evidence supported that Tai Chi alleviated pain among women with BC ($SMD_{3\ weeks}$=0.27, 95% CI 0.11 to 0.44; $SMD_{12\ weeks}$=0.30, 95% CI 0.08 to 0.51).[81] Similarly, HIIT and combined HIIT programmes have been linked to pain reduction in patients with cancer (SMD=0.44, 95% CI 0.24 to 0.65).[82]

Social function

Yoga enhanced social well-being in women with BC (MD=1.36, 95% CI 0.12 to 2.61).[86] Furthermore, exercise improved social function (SMD=0.18, 95% CI 0.02 to 0.34), and the rate of return to work (RR=1.31, 95% CI 1.18 to 1.46) among people with cancer.[57 87] These associations were supported by moderate-certainty evidence.

Sensitivity analyses

Several sensitivity analyses of significant associations with certainty greater than moderate according to GRADE were conducted. Excluding studies with a high risk of bias effectively mitigated bias.[42] Consequently, four associations were upgraded from moderate to high certainty: supervised exercise improved QoL,[88] exercise during treatment enhanced physical function,[76] HIIT alleviated cancer-related fatigue[82] and programmes that integrated yoga or focused on spiritual growth alongside physical activity alleviated symptoms of depression (online supplemental table 7).[74] Compared with the largest trial in the meta-analysis, smaller and medium-sized trials exhibited greater treatment effects.[89–92] After excluding RCTs with small sample sizes (below the 25th percentile), the evidence level for five associations was downgraded from moderate to low. The involved outcomes included cognitive function[16] and fatigue (online supplemental table 8).[85] Additionally, 21 associations were excluded owing to overlap. Certainty was upgraded for two associations.[52 85] Seven associations were downgraded,[76 79 93–97] while 12 associations maintained their original certainty status (online supplemental table 9).[55 63 76 79 96 98 99] Finally, these associations excluded owing to insufficient data for quantitative synthesis are summarised in online supplemental table 10, showing general alignment with the main findings.

DISCUSSION

This UR provides a detailed assessment, confirming that exercise significantly improves various health outcomes in patients with cancer.

Exercise effectively reduces adverse effects of cancer and its treatments

Cancer surgery often leads to high postoperative complication rates, hindering recovery and increasing healthcare costs.[100–102] Preoperative interventions, including exercise, nutrition and psychological support, have gained attention for optimising health and reducing complications.[103–107] The findings confirmed that preoperative AE and RE moderately reduced pain and dyspnoea in patients with lung cancer undergoing surgery, shortened hospital stays and decreased complication rates.[55 56]

Chemotherapy and targeted therapies can cause cognitive impairment, peripheral neuropathy and cardiotoxicity.[108–110] Exercise, with its anti-inflammatory and neuroprotective properties,[111 112] improves cerebral perfusion and supports the development of the prefrontal cortex and hippocampus.[113 114] Our findings confirmed that AE and RE moderately enhance cognitive function in patients with BC undergoing haematopoietic stem cell transplantation, aligning with prior research.[115–117] Mind–body exercises such as yoga, Tai Chi and Qigong improved cognitive function in patients with lung cancer. However, the level of evidence for this association was downgraded from moderate to low in sensitivity analyses after excluding small sample sizes. Therefore, further research with larger sample sizes is necessary to fully elucidate the potential benefits of mind–body exercises on cognitive function in this cancer population.

The impact of exercise on CIPN symptoms is debated, but most studies, including ours, showed significant improvements.[22 23 118 119] Multifaceted regimens with nerve gliding and sensory-motor-based strategies effectively alleviated CIPN symptoms and postural stability deficits.[53] Neurosensory exercises are emphasised as beneficial for cancer populations with CIPN. Regarding cardiotoxicity, AE mitigated chemotherapy-induced effects by preserving LVEF and improving cardiorespiratory function.[52] However, evidence on its effectiveness when combined with chemotherapy is mixed, with some studies showing no impact on LVEF but reduced strain damage.[26 27] Further research is needed to clarify the role of exercise in preventing cardiotoxicity.

Exercise improves body composition, manages obesity and regulates biomarker expression in people with cancer

Individuals undergoing treatment for breast or prostate cancer, often experience weight gain or obesity.[120–122] Obesity disrupts physiological processes, creating a tumor-promoting microenvironment.[123] Our findings indicated that varied exercises (AE, combined exercise, mind–body exercise and RE) reduced obesity, lowered body fat and improved lean body mass. It is important to highlight those studies exclusively comprising people with stage II+ BC, where a slight increase in BMI was observed following supervised exercise interventions. However, when studies included people with various types of cancer who underwent Tai Chi interventions, BMI declined. This discrepancy might be partly attributed to differences in exercise modalities. Supervised programmes may include resistance training, which could increase muscle mass and raise BMI,[124] whereas Tai Chi, a low-impact exercise, may promote weight loss.[125] Sensitivity analysis focusing on high-quality RCTs confirmed that exercise significantly lowers BMI (MD=−0.60, 95% CI −1.16 to –0.03) and renders the BMI increase non-significant (SMD=0.12, 95% CI −0.09 to 0.33). Thus, initial BMI increases should be interpreted cautiously, emphasising the need for more high-quality studies and tailored approaches to exercise.

Clinical research has shown that the IGF-1/IGF-1R axis and elevated IGF-1 levels are associated with cancer progression,[126–128] poor prognoses[129] and increased all-cause mortality.[129] Insulin and IGF-1 activate the PI3K/Akt/mTOR and Ras/Raf/MAPK signalling pathways and promote tumour proliferation. Our findings indicated that AE, RE and mind–body exercises reduced serum concentrations of IGF-1 and IGFBP-1 in BC survivors. CRP is a well-established marker of inflammation in cancer,[130] and raised CRP levels are associated with advanced disease stages in various types of cancer.[131–134] Our findings indicated that a combination of AE and RE was particularly effective in reducing serum insulin and CRP levels in BC survivors.[62] Moderate-intensity AE significantly reduced CRP levels in people with stage III colon cancer, but showed no substantial effect in stage I–II colon cancer.[135] Similarly, individualised exercise programmes effectively lowered CRP levels in people with lung cancer undergoing chemotherapy,[136] whereas no significant impact was observed in people with ovarian cancer.[137] These findings highlight the need for future research to delineate the variations across different types of cancer and to comprehensively investigate the mechanisms by which exercise regulates these biomarkers, as well as their potential clinical implications.

Exercise improves sleep quality, overall QoL and psychological outcomes among people with cancer

Cancer diagnosis and treatment often lead to psychological distress, with moderate to severe depression affecting 15% of people, and mild depression and anxiety at rates of 20% and 10%, respectively.[138 139] Long-term survivors also face heightened risks of depression and anxiety.[140] Our findings suggested that taking part in exercise greatly enhanced sleep quality, reduced insomnia and alleviated anxiety and depression in people with cancer, thus improving their overall QoL. Specifically, yoga and comprehensive exercise have been shown to positively affect sleep quality,[66 67] while Tai Chi and Qigong were effective in reducing anxiety.[71] Interventions combining yoga or spiritual growth with physical activity, as well as exercise post-radiotherapy or post-diagnosis, are supported by moderate evidence indicating their potential to alleviate depression.[72–74] Notably, exercise improved QoL across various cancer types, including BC, lung cancer, and among elderly people with CRC undergoing chemotherapy.[68 69] Additionally, yoga was found to enhance short-term health-related QoL in BC.[65] Our findings highlighted the significant benefits of mind–body exercises (Tai Chi, yoga and Qigong) in improving sleep, addressing emotional challenges and enhancing QoL in people with cancer. This provides a valuable complement to existing guidelines, which mainly emphasise moderate to high-intensity AE and RE.[8 9 141 142]

Exercise improves the physiological and social function of people with cancer

Up to 80% of cancer populations experience significant $VO2_{peak}$ impairment,[143] which is strongly linked to higher treatment-related toxicity,[144] poor QoL,[145] fatigue[146] and increased mortality.[143 147] Exercise therapy has been shown to significantly improve $VO2_{peak}$, especially in patients with BC.[19] Our study showed that exercising during chemotherapy resulted in greater $VO2_{peak}$ improvements compared with post-chemotherapy exercise, particularly in people with breast, colon and other cancers.

These findings highlighte the critical importance of maintaining an exercise regimen throughout the entire chemotherapy period.

HIIT, AE and RE significantly improved body strength and aerobic capacity, with HIIT notably alleviating cancer-related fatigue and pain. These findings aligned with the conclusions of the OptiTrain Trial,[148 149] which confirmed that RE and HIIT during chemotherapy improved muscle strength, reduced pain sensitivity and prevented cardiopulmonary decline in people with BC. Mind–body exercises like yoga, aerobic resistance interval training and Tai Chi also enhanced physical functioning,[16] including in those with advanced stage disease.[57] Tai Chi and progressive resistance training were particularly effective for bolstering lower-body strength.[150] Tai Chi improved shoulder function in people with BC within 3 weeks and effectively reduced pain and enhanced arm strength by 12 weeks.[81] Social support plays a vital role in stress management and trauma recovery for those with cancer.[151 152] Given that cancer often reduces social interactions, our research showed that regular exercise improves social functionality, increases the likelihood of returning to work, and notably, yoga significantly enhances overall social well-being.

Strengths and limitations of the study

We conducted a comprehensive and up-to-date assessment of systematic reviews and meta-analyses on the health outcomes of exercise in people with cancer. A thorough search across authoritative databases was followed by independent screening, data extraction, recalculations of effect sizes and methodological quality evaluations using AMSTAR criteria, with sensitivity analyses ensuring robust findings. Only RCT-based meta-analyses were included, enhancing reliability and accuracy, with 49% of associations rated as high or moderate certainty based on GRADE guidelines. Our study encompasses a broad spectrum of health outcomes, diverse cancer types and exercise interventions, including not only aerobic and resistance training but also mind–body practices. This broad and clinically significant approach provides valuable, generalisable insights for improving QoL in cancer populations and informing fitness and healthcare professionals.

Several limitations of our study need to be acknowledged. First, the GRADE assessment indicated heterogeneity ($I^2 > 50\%$) and imprecision (continuous variables with total population size <400; binary categorical variables with events <300) in various meta-analyses. One potential contributing factor is the small sample sizes—48% of meta-analyses included fewer than five original studies—resulting in inconsistent findings and imprecise estimates. This affected outcomes such as anxiety, adiponectin levels, glucose levels, interleukin-10/interleukin-6 ratios, tumour necrosis factor-α levels and vascular endothelial growth factor expression. Variability in handling diverse effect estimates, despite their conceptual comparability, and differences in cancer types, exercise parameters (eg, intensity, duration, frequency), outcome assessment criteria and follow-up periods further contributed to heterogeneity and low-certainty evidence for certain outcomes like cognitive function, early-to-atrial filling velocity ratio and cardiorespiratory fitness. However, low-certainty evidence does not negate potential associations, particularly as future studies generate more data.

Second, the broad nature of an UR limited our ability to account for specific confounding factors or mediators related to exercise interventions. Most current evidence on the effectiveness of exercise during or after cancer treatment derived from RCTs involving supervised or home-based exercise, primarily focusing on survivors of common cancers (eg, breast and lung cancer). These participants often met strict eligibility criteria—such as age, comorbidities and physical capability—leading to samples that were healthier and more motivated than the broader cancer populations. It is recognised that demographic differences, including treatment side effects, vary among cancer populations by type of malignancy; therefore, more research is needed to enhance specificity within exercise oncology literature to better address a wider range of cancer types and stages.

CONCLUSION

In conclusion, this study reinforces the efficacy of incorporating exercise into cancer treatment protocols. Moderate- to high-certainty evidence showed that exercise, compared with usual care or no exercise, significantly reduced cancer-related adverse events (eg, cardiotoxicity, CIPN, cognitive impairment and dyspnoea), improved body composition and biomarkers (eg, insulin, IGF-1, IGFBP-1 and CRP), enhanced sleep quality, psychological well-being, physical function, social interaction and overall QoL. Incorporating mind–body exercises into the exercise guidelines for people with cancer may be a valuable consideration. Future high-quality research is needed to explore additional outcomes, clarify underlying mechanisms and refine exercise prescriptions tailored to cancer type, treatment timing, exercise modality and individual characteristics, ensuring more precise and clinically relevant interventions for diverse cancer populations.

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REFERENCES

1 Bray F, Laversanne M, Weiderpass E, *et al*. The ever-increasing importance of cancer as a leading cause of premature death worldwide. *Cancer* 2021;127:3029–30.
2 Bray F, Laversanne M, Sung H, *et al*. Global cancer statistics 2022: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *CA Cancer J Clin* 2024;74:229–63.
3 International WCRF. Diet, nutrition, physical activity and cancer: a global perspective. Continuous update project report. 2018. Available: https://www.wcrf.org/dietandcancer
4 World Health Organization. Physical activity. fact sheet 385. 2024. Available: www.who.int/mediacentre/factsheets/fs385/en/
5 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;51:2375–90.
6 Schmitz KH, Courneya KS, Matthews C, *et al*. American College of Sports Medicine roundtable on exercise guidelines for cancer survivors. *Med Sci Sports Exerc* 2010;42:1409–26.
7 Ligibel JA, Bohlke K, May AM, *et al*. Exercise, Diet, and Weight Management During Cancer Treatment: ASCO Guideline. *J Clin Oncol* 2022;40:2491–507.
8 Cormie P, Atkinson M, Bucci L, *et al*. Clinical Oncology Society of Australia position statement on exercise in cancer care. *Med J Aust* 2018;209:184–7.
9 da Silva T. Appraisal of Clinical Practice Guideline: Exercise for people with cancer. *J Physiother* 2018;64:127.
10 Cancer Research UK. Exercise guidelines for cancer patients. 2023. Available: https://www.cancerresearchuk.org/about-cancer/coping/physically/exercise-guidelines
11 Tsai CH, Chiang PH. More Benefits of Tai Chi Than Aerobic Exercise in Patients With Advanced Lung Cancer. *JAMA Oncol* 2024;10:1290–1.
12 Carmady B, Smith CA. Use of Chinese medicine by cancer patients: a review of surveys. *Chin Med* 2011;6:22.
13 Oh B, Butow P, Mullan B, *et al*. Impact of medical Qigong on quality of life, fatigue, mood and inflammation in cancer patients: a randomized controlled trial. *Ann Oncol* 2010;21:608–14.
14 Takemura N, Cheung DST, Smith R, *et al*. Effectiveness of aerobic exercise and mind-body exercise in cancer patients with poor sleep quality: A systematic review and meta-analysis of randomized controlled trials. *Sleep Med Rev* 2020;53:101334.
15 Bailey LE, Morris MA. Mind-body therapies adjuvant to chemotherapy improve quality of life and fatigue in top cancers: A systematic review and meta-analysis. *Complement Ther Clin Pract* 2024;54:101811.
16 Sun J, Chen D, Qin C, *et al*. The effect of mind-body exercise in lung cancer patients: a meta-analysis of RCTs. *Support Care Cancer* 2023;31:650.
17 Wayne PM, Lee MS, Novakowski J, *et al*. Tai Chi and Qigong for cancer-related symptoms and quality of life: a systematic review and meta-analysis. *J Cancer Surviv* 2018;12:256–67.
18 Zou H, Lin X, Duan T, *et al*. Simple Sitting Baduanjin mind-body exercise: randomized controlled trial protocol for advanced cancer patients with the fatigue-sleep disturbance symptom cluster. *BMC Complement Med Ther* 2024;24:348.
19 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;36:2297–305.
20 Fong DYT, Ho JWC, Hui BPH, *et al*. Physical activity for cancer survivors: meta-analysis of randomised controlled trials. *BMJ* 2012;344:e70.
21 Chen YW, Hunt MA, Campbell KL, *et al*. The effect of Tai Chi on four chronic conditions—cancer, osteoarthritis, heart failure and chronic obstructive pulmonary disease: a systematic review and meta-analyses. *Br J Sports Med* 2016;50:397–407.
22 Cao A, Cartmel B, Li F-Y, *et al*. Effect of Exercise on Chemotherapy-Induced Peripheral Neuropathy Among Patients Treated for Ovarian Cancer: A Secondary Analysis of a Randomized Clinical Trial. *JAMA Netw Open* 2023;6:e2326463.
23 Guo S, Han W, Wang P, *et al*. Effects of exercise on chemotherapy-induced peripheral neuropathy in cancer patients: a systematic review and meta-analysis. *J Cancer Surviv* 2023;17:318–31.
24 Salerno EA, Culakova E, Kleckner AS, *et al*. Physical Activity Patterns and Relationships With Cognitive Function in Patients With Breast Cancer Before, During, and After Chemotherapy in a Prospective, Nationwide Study. *JCO* 2021;39:3283–92.
25 Naaktgeboren WR, Koevoets EW, Stuiver MM, *et al*. Effects of physical exercise during adjuvant chemotherapy for breast cancer on long-term tested and perceived cognition: results of a pragmatic follow-up study. *Breast Cancer Res Treat* 2024;205:75–86.
26 Murray J, Bennett H, Bezak E, *et al*. The role of exercise in the prevention of cancer therapy-related cardiac dysfunction in breast cancer patients undergoing chemotherapy: systematic review. *Eur J Prev Cardiol* 2022;29:463–72.
27 Linhares BG, Linhares DG, Boppre G, *et al*. New insights into cardioprotection in breast cancer patients undergoing physical exercise during chemotherapy: A systematic review and meta-analysis. *Curr Probl Cardiol* 2024;49:102743.
28 Lin D, Sturgeon KM, Gordon BR, *et al*. WISER Survivor Trial: Combined Effect of Exercise and Weight Loss Interventions on Adiponectin and Leptin Levels in Breast Cancer Survivors with Overweight or Obesity. *Nutrients* 2023;15:3453.
29 Dieli-Conwright CM, Courneya KS, Demark-Wahnefried W, *et al*. Effects of Aerobic and Resistance Exercise on Metabolic Syndrome, Sarcopenic Obesity, and Circulating Biomarkers in Overweight or Obese Survivors of Breast Cancer: A Randomized Controlled Trial. *J Clin Oncol* 2018;36:875–83.
30 Fairey AS, Courneya KS, Field CJ, *et al*. Effect of exercise training on C-reactive protein in postmenopausal breast cancer survivors: a randomized controlled trial. *Brain Behav Immun* 2005;19:381–8.
31 Michigan A, Johnson TV, Master VA. Review of the relationship between C-reactive protein and exercise. *Mol Diagn Ther* 2011;15:265–75.
32 Irwin ML, Varma K, Alvarez-Reeves M, *et al*. Randomized Controlled Trial of Aerobic Exercise on Insulin and Insulin-like Growth Factors in Breast Cancer Survivors: The Yale Exercise and Survivorship Study. *Cancer Epidemiol Biomarkers Prev* 2009;18:306–13.
33 Sprod LK, Janelsins MC, Palesh OG, *et al*. Health-related quality of life and biomarkers in breast cancer survivors participating in tai chi chuan. *J Cancer Surviv* 2012;6:146–54.
34 World Cancer Research Fund International. After a cancer diagnosis follow our recommendations, if you can. 2018. Available: https://www.wcrf.org/diet-activity-and-cancer/cancer-prevention-recommendations/after-a-cancer-diagnosis-follow-our-recommendations-if-you-can/
35 Fusar-Poli P, Radua J. Ten simple rules for conducting umbrella reviews. *Evid Based Ment Health* 2018;21:95–100.
36 Ioannidis J. Next-generation systematic reviews: prospective meta-analysis, individual-level data, networks and umbrella reviews. *Br J Sports Med* 2017;51:1456–8.
37 Ioannidis JPA. Integration of evidence from multiple meta-analyses: a primer on umbrella reviews, treatment networks and multiple treatments meta-analyses. *Can Med Assoc J* 2009;181:488–93.
38 Moher D, Liberati A, Tetzlaff J, *et al*. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *PLoS Med* 2009;6:e1000097.
39 Shea BJ, Reeves BC, Wells G, *et al*. AMSTAR 2: a critical appraisal tool for systematic reviews that include randomised or non-randomised studies of healthcare interventions, or both. *BMJ* 2017;358:j4008.
40 Shea BJ, Grimshaw JM, Wells GA, *et al*. Development of AMSTAR: a measurement tool to assess the methodological quality of systematic reviews. *BMC Med Res Methodol* 2007;7:10.
41 Cao F, Li Y-Z, Zhang D-Y, *et al*. Human papillomavirus infection and the risk of cancer at specific sites other than anogenital tract and oropharyngeal region: an umbrella review. *EBioMedicine* 2024;104:105155.
42 Guyatt GH, Oxman AD, Vist GE, *et al*. GRADE: an emerging consensus on rating quality of evidence and strength of recommendations. *BMJ* 2008;336:924–6.
43 Guyatt G, Oxman AD, Akl EA, *et al*. GRADE guidelines: 1. Introduction—GRADE evidence profiles and summary of findings tables. *J Clin Epidemiol* 2011;64:383–94.
44 DerSimonian R, Laird N. Meta-analysis in clinical trials. *Control Clin Trials* 1986;7:177–88.
45 Aromataris E, Fernandez R, Godfrey CM, *et al*. Summarizing systematic reviews: methodological development, conduct and reporting of an umbrella review approach. *Int J Evid Based Healthc* 2015;13:132–40.
46 Higgins JPT, Thompson SG, Deeks JJ, *et al*. Measuring inconsistency in meta-analyses. *BMJ* 2003;327:557–60.
47 Cohen J. Statistical Power Analysis for the Behavioral Sciences. Lawrence Erlbaum Associates, 1988.
48 Dechartres A, Altman DG, Trinquart L, *et al*. Association between analytic strategy and estimates of treatment outcomes in meta-analyses. *JAMA* 2014;312:623–30.
49 Sun M-L, Yao W, Wang X-Y, *et al*. Intermittent fasting and health outcomes: an umbrella review of systematic reviews and meta-analyses of randomised controlled trials. *EClinicalMedicine* 2024;70:102519.
50 Higgins JPT, Altman DG, Gotzsche PC, *et al*. The Cochrane Collaboration's tool for assessing risk of bias in randomised trials. *BMJ* 2011;343:d5928.
51 Mackenzie L, Marshall K. Effective non-pharmacological interventions for cancer related cognitive impairment in adults (excluding central nervous system or head and neck cancer): systematic review and meta-analysis. *Eur J Phys Rehabil Med* 2022;58:258–70.

52 Tsai YL, Chuang YC, Chen CP, *et al*. Feasibility of Aerobic Exercise Training to Mitigate Cardiotoxicity of Breast Cancer Therapy: A Systematic Review and Meta-Analysis. *Clin Breast Cancer* 2023;23:576–90.
53 Lin WL, Wang RH, Chou FH, *et al*. The effects of exercise on chemotherapy-induced peripheral neuropathy symptoms in cancer patients: a systematic review and meta-analysis. *Support Care Cancer* 2021;29:5303–11.
54 Pan Y, Yang K, Wang Y, *et al*. Could yoga practice improve treatment-related side effects and quality of life for women with breast cancer? A systematic review and meta-analysis. *Asia Pac J Clin Oncol* 2017;13:e79–95.
55 Rosero ID, Ramírez-Vélez R, Lucia A, *et al*. Systematic Review and Meta-Analysis of Randomized, Controlled Trials on Preoperative Physical Exercise Interventions in Patients with Non-Small-Cell Lung Cancer. *Cancers (Basel)* 2019;11:944.
56 Gravier F-E, Smondack P, Prieur G, *et al*. Effects of exercise training in people with non-small cell lung cancer before lung resection: a systematic review and meta-analysis. *Thorax* 2022;77:486–96.
57 Chen Y, Li X, Ma H, *et al*. Exercise Training for Improving Patient-Reported Outcomes in Patients With Advanced-Stage Cancer: A Systematic Review and Meta-Analysis. *J Pain Symptom Manage* 2020;59:734–49.
58 Morishita S, Hamaue Y, Fukushima T, *et al*. Effect of Exercise on Mortality and Recurrence in Patients With Cancer: A Systematic Review and Meta-Analysis. *Integr Cancer Ther* 2020;19:1534735420917462.
59 Singh B, Spence RR, Steele ML, *et al*. A Systematic Review and Meta-Analysis of the Safety, Feasibility, and Effect of Exercise in Women With Stage II+ Breast Cancer. *Arch Phys Med Rehabil* 2018;99:2621–36.
60 Soares Falcetta F, de Araújo Vianna Träsel H, de Almeida FK, *et al*. Effects of physical exercise after treatment of early breast cancer: systematic review and meta-analysis. *Breast Cancer Res Treat* 2018;170:455–76.
61 Shao W, Zhang H, Qi H, *et al*. The effects of exercise on body composition of prostate cancer patients receiving androgen deprivation therapy: An update systematic review and meta-analysis. *PLoS One* 2022;17:e0263918.
62 Liang Z, Zhang M, Shi F, *et al*. Comparative efficacy of four exercise types on obesity-related outcomes in breast cancer survivors: A Bayesian network meta-analysis. *Eur J Oncol Nurs* 2023;66:102423.
63 Zhou Y, Jia N, Ding M, *et al*. Effects of exercise on inflammatory factors and IGF system in breast cancer survivors: a meta-analysis. *BMC Womens Health* 2022;22:507.
64 Meneses-Echávez JF, Jiménez EG, Río-Valle JS, *et al*. The insulin-like growth factor system is modulated by exercise in breast cancer survivors: a systematic review and meta-analysis. *BMC Cancer* 2016;16:682.
65 Cramer H, Lauche R, Klose P, *et al*. Yoga for improving health-related quality of life, mental health and cancer-related symptoms in women diagnosed with breast cancer. *Cochrane Database Syst Rev* 2017;1:CD010802.
66 Gururaj R, Samuel SR, Kumar KV, *et al*. Effect of exercise based interventions on sleep and circadian rhythm in cancer survivors—a systematic review and meta-analysis. *PeerJ* 2024;12:e17053.
67 Kreutz C, Schmidt ME, Steindorf K. Effects of physical and mind-body exercise on sleep problems during and after breast cancer treatment: a systematic review and meta-analysis. *Breast Cancer Res Treat* 2019;176:1–15.
68 Machado P, Pimenta S, Oliveiros B, *et al*. Effect of Exercise Training on Quality of Life after Colorectal and Lung Cancer Surgery: A Meta-Analysis. *Cancers (Basel)* 2021;13:4975.
69 Lund CM, Dolin TG, Mikkelsen MK, *et al*. Effect of Exercise on Physical Function and Psychological Well-being in Older Patients With Colorectal Cancer Receiving Chemotherapy-A Systematic Review. *Clin Colorectal Cancer* 2020;19:e243–57.
70 Wang T-C, Chen P-L, Liao W-C, *et al*. Differential Impact of Exercises on Quality-of-Life Improvement in Breast Cancer Survivors: A Network Meta-Analysis of Randomized Controlled Trials. *Cancers (Basel)* 2023;15:3380.
71 Sun F, Li L, Wen X, *et al*. The effect of Tai Chi/Qigong on depression and anxiety symptoms in adults with Cancer: A systematic review and meta-regression. *Complement Ther Clin Pract* 2024;56:101850.
72 Salam A, Woodman A, Chu A, *et al*. Effect of post-diagnosis exercise on depression symptoms, physical functioning and mortality in breast cancer survivors: A systematic review and meta-analysis of randomized control trials. *Cancer Epidemiol* 2022;77:102111.
73 Shen Q, Yang H. Impact of post-radiotherapy exercise on women with breast cancer: A systematic review and meta-analysis of randomized controlled trials. *J Rehabil Med* 2020;52:jrm00112.
74 Coutiño-Escamilla L, Piña-Pozas M, Tobías Garces A, *et al*. Non-pharmacological therapies for depressive symptoms in breast cancer patients: Systematic review and meta-analysis of randomized clinical trials. *Breast* 2019;44:135–43.
75 Zeng J, Wu J, Tang C, *et al*. Effects of Exercise During or Postchemotherapy in Cancer Patients: A Systematic Review and Meta-Analysis. *Worldviews Evid Based Nurs* 2019;16:92–101.
76 Juvet LK, Thune I, Elvsaas IKØ, *et al*. The effect of exercise on fatigue and physical functioning in breast cancer patients during and after treatment and at 6 months follow-up: A meta-analysis. *The Breast* 2017;33:166–77.
77 Toohey K, Hunter M, Paterson C, *et al*. Clinical updates on the effects of high intensity interval training (HIIT) exercise in people diagnosed with cancer. A systematic review and meta-analysis. *J Sci Med Sport* 2023;26:667–75.
78 Li C-Q, Wang Y-C, Shen S-Q, *et al*. Effects of exercise by type and duration on quality of life in patients with digestive system cancers: A systematic review and network meta-analysis. *J Sport Health Sci* 2023;12:491–500.
79 Paramanandam VS, Roberts D. Weight training is not harmful for women with breast cancer-related lymphoedema: a systematic review. *J Physiother* 2014;60:136–43.
80 Cramer H, Lauche R, Klose P, *et al*. A systematic review and meta-analysis of exercise interventions for colorectal cancer patients. *Eur J Cancer Care (Engl)* 2014;23:3–14.
81 Luo X-C, Liu J, Fu J, *et al*. Effect of Tai Chi Chuan in Breast Cancer Patients: A Systematic Review and Meta-Analysis. *Front Oncol* 2020;10:607.
82 Wang L, Quan M, Nieman DC, *et al*. Effects of High-Intensity Interval Training and Combined High-Intensity Interval Training Programs on Cancer-Related Fatigue and Cancer Pain: A Systematic Review and Meta-analysis. *Med Sci Sports Exerc* 2023;55:1620–31.
83 Liu A-I, Lee Y-H, Lu C-Y, *et al*. Effects of Walking Combined With Resistance Band Exercises on Alleviating Cancer-Related Fatigue: A Systematic Review and Meta-analysis of Randomized Controlled Trials. *Cancer Nurs* 2023;8.
84 Mok J, Brown M-J, Akam EC, *et al*. The lasting effects of resistance and endurance exercise interventions on breast cancer patient mental wellbeing and physical fitness. *Sci Rep* 2022;12:3504.
85 Penna GB, Otto DM, da Silva TC, *et al*. Physical rehabilitation for the management of cancer-related fatigue during cytotoxic treatment: a systematic review with meta-analysis. *Support Care Cancer* 2023;31.
86 Hsueh E-J, Loh E-W, Lin JJ-A, *et al*. Effects of yoga on improving quality of life in patients with breast cancer: a meta-analysis of randomized controlled trials. *Breast Cancer* 2021;28:264–76.
87 Wilson TN, Nambiema A, Porro B, *et al*. Effectiveness of Physical Activity Interventions on Return to Work After a Cancer Diagnosis: A Systematic Review and Meta-analysis. *J Occup Rehabil* 2023;33:4–19.
88 Buffart LM, Kalter J, Sweegers MG, *et al*. Effects and moderators of exercise on quality of life and physical function in patients with cancer: An individual patient data meta-analysis of 34 RCTs. *Cancer Treat Rev* 2017;52:91–104.
89 Nüesch E, Trelle S, Reichenbach S, *et al*. Small study effects in meta-analyses of osteoarthritis trials: meta-epidemiological study. *BMJ* 2010;341:c3515.
90 Dechartres A, Trinquart L, Boutron I, *et al*. Influence of trial sample size on treatment effect estimates: meta-epidemiological study. *BMJ* 2013;346:f2304.
91 Pereira TV, Horwitz RI, Ioannidis JPA. Empirical evaluation of very large treatment effects of medical interventions. *JAMA* 2012;308:1676–84.
92 Pereira TV, Ioannidis JPA. Statistically significant meta-analyses of clinical trials have modest credibility and inflated effects. *J Clin Epidemiol* 2011;64:1060–9.
93 Jung Y, Chung J, Son H. Physical Activity Interventions for Colorectal Cancer Survivors: A Systematic Review and Meta-analysis of Randomized Controlled Trials. *Cancer Nurs* 2021;44:E414–28.
94 Meneses-Echavez JF, Loaiza-Betancur AF, Díaz-López V, *et al*. Prehabilitation programs for individuals with cancer: a systematic review of randomized-controlled trials. *Syst Rev* 2023;12:219.
95 Cavalheri V, Granger C. Preoperative exercise training for patients with non-small cell lung cancer. *Cochrane Database Syst Rev* 2017;6:CD012020.
96 Kang DW, Lee J, Suh SH, *et al*. Effects of Exercise on Insulin, IGF Axis, Adipocytokines, and Inflammatory Markers in Breast Cancer Survivors: A Systematic Review and Meta-analysis. *Cancer Epidemiol Biomarkers Prev* 2017;26:355–65.
97 Yan JH, Pan L, Zhang XM, *et al*. Lack of efficacy of Tai Chi in improving quality of life in breast cancer survivors: a systematic review and meta-analysis. *Asian Pac J Cancer Prev* 2014;15:3715–20.
98 Lee J, Lee MG. Effects of Exercise Interventions on Breast Cancer Patients During Adjuvant Therapy: A Systematic Review and Meta-analysis of Randomized Controlled Trials. *Cancer Nurs* 2020;43:115–25.
99 Fornusek CP, Kilbreath SL. Exercise for improving bone health in women treated for stages I-III breast cancer: a systematic review and meta-analyses. *J Cancer Surviv* 2017;11:525–41.
100 Steffens D, Solomon MJ, Jack S, *et al*. ASO Author Reflections: Improving Postoperative Outcomes in Colorectal Cancer Surgery: Where are We with Prehabilitation? *Ann Surg Oncol* 2024;31:6474–5.
101 Tohme S, Simmons RL, Tsung A. Surgery for Cancer: A Trigger for Metastases. *Cancer Res* 2017;77:1548–52.
102 Grewal S, Oosterling SJ, van Egmond M. Surgery for Colorectal Cancer: A Trigger for Liver Metastases Development? New Insights into the Underlying Mechanisms. *Biomedicines* 2021;9:177.
103 Steffens D, Hancock M, Jiang W, *et al*. An Updated Systematic Review and Meta-Analysis of Unimodal Prehabilitation with Exercise Intervention to Enhance Postoperative Outcomes in Cancer Surgery. *Anesth Analg* 2024.
104 Steffens D, Denehy L. Prehabilitation exercise programs for patients undergoing cancer surgery, does one size fit all? *Eur J Surg Oncol* 2023;49:303–5.
105 Strijker D, Drager L, van Asseldonk M, *et al*. Multimodal prehabilitation (Fit4Surgery) in high-impact surgery to enhance surgical outcomes: Study protocol of F4S PREHAB, a single center stepped wedge trial. *PLoS One* 2024;19:e0303829.

106 Steffens D, Nott F, Koh C, *et al*. Effectiveness of Prehabilitation Modalities on Postoperative Outcomes Following Colorectal Cancer Surgery: A Systematic Review of Randomised Controlled Trials. *Ann Surg Oncol* 2024;31:7822–49.
107 Hirst N, McBride K, Steffens D. Psychological Interventions in Prehabilitation Randomized Controlled Trials for Patients Undergoing Cancer Surgery: Sufficient or Suboptimal? *Ann Surg Oncol* 2024;31:2183–6.
108 Elshafie S, Trivedi R, Villa-Zapata LA, *et al*. Adherence, clinical benefits, and adverse effects of endocrine therapies among women with nonmetastatic breast cancer in developing countries: A systematic review and meta-analysis. *Cancer* 2025;131:e35550.
109 Galvão DA, Taaffe DR, Spry N, *et al*. Combined Resistance and Aerobic Exercise Program Reverses Muscle Loss in Men Undergoing Androgen Suppression Therapy for Prostate Cancer Without Bone Metastases: A Randomized Controlled Trial. *JCO* 2010;28:340–7.
110 Mundell NL, Daly RM, Macpherson H, *et al*. Cognitive decline in prostate cancer patients undergoing ADT: a potential role for exercise training. *Endocr Relat Cancer* 2017;24:R145–55.
111 Stillman CM, Esteban-Cornejo I, Brown B, *et al*. Effects of Exercise on Brain and Cognition Across Age Groups and Health States. *Trends Neurosci* 2020;43:533–43.
112 Gleeson M, Bishop NC, Stensel DJ, *et al*. The anti-inflammatory effects of exercise: mechanisms and implications for the prevention and treatment of disease. *Nat Rev Immunol* 2011;11:607–15.
113 Maass A, Düzel S, Goerke M, *et al*. Vascular hippocampal plasticity after aerobic exercise in older adults. *Mol Psychiatry* 2015;20:585–93.
114 Ainslie PN, Cotter JD, George KP, *et al*. Elevation in cerebral blood flow velocity with aerobic fitness throughout healthy human ageing. *J Physiol (Lond)* 2008;586:4005–10.
115 Campbell KL, Kam JWY, Neil-Sztramko SE, *et al*. Effect of aerobic exercise on cancer-associated cognitive impairment: A proof-of-concept RCT. *Psychooncology* 2018;27:53–60.
116 Galiano-Castillo N, Cantarero-Villanueva I, Fernández-Lao C, *et al*. Telehealth system: A randomized controlled trial evaluating the impact of an internet-based exercise intervention on quality of life, pain, muscle strength, and fatigue in breast cancer survivors. *Cancer* 2016;122:3166–74.
117 Galiano-Castillo N, Arroyo-Morales M, Lozano-Lozano M, *et al*. Effect of an Internet-based telehealth system on functional capacity and cognition in breast cancer survivors: a secondary analysis of a randomized controlled trial. *Support Care Cancer* 2017;25:3551–9.
118 Brownson-Smith R, Orange ST, Cresti N, *et al*. Effect of exercise before and/or during taxane-containing chemotherapy treatment on chemotherapy-induced peripheral neuropathy symptoms in women with breast cancer: systematic review and meta-analysis. *J Cancer Surviv* 2025;19:78–96.
119 Burgess J, Ferdousi M, Gosal D, *et al*. Chemotherapy-Induced Peripheral Neuropathy: Epidemiology, Pathomechanisms and Treatment. *Oncol Ther* 2021;9:385–450.
120 Picon-Ruiz M, Morata-Tarifa C, Valle-Goffin JJ, *et al*. Obesity and adverse breast cancer risk and outcome: Mechanistic insights and strategies for intervention. *CA Cancer J Clin* 2017;67:378–97.
121 Galvão DA, Spry NA, Taaffe DR, *et al*. Changes in muscle, fat and bone mass after 36 weeks of maximal androgen blockade for prostate cancer. *BJU Int* 2008;102:44–7.
122 Spry NA, Taaffe DR, England PJ, *et al*. Long-term effects of intermittent androgen suppression therapy on lean and fat mass: a 33-month prospective study. *Prostate Cancer Prostatic Dis* 2013;16:67–72.
123 Iyengar NM, Gucalp A, Dannenberg AJ, *et al*. Obesity and Cancer Mechanisms: Tumor Microenvironment and Inflammation. *J Clin Oncol* 2016;34:4270–6.
124 Artigas-Arias M, Alegría-Molina A, Vidal-Seguel N, *et al*. Skeletal muscle mass, strength, and physical performance gains are similar between healthy postmenopausal women and postmenopausal breast cancer survivors after 12 weeks of resistance exercise training. *Support Care Cancer* 2024;32:818.
125 Wang CC, Geraghty S, Fox-Harding C, *et al*. Effects of a nurse-led Tai Chi programme on improving quality of life, mental wellbeing, and physical function of women with breast cancer: Protocol for a randomized controlled trial. *Womens Health (Lond Engl)* 2022;18:17455057221127813.
126 Arcidiacono B, Iiritano S, Nocera A, *et al*. Insulin resistance and cancer risk: an overview of the pathogenetic mechanisms. *Exp Diabetes Res* 2012;2012:789174.
127 Bowers LW, Rossi EL, O'Flanagan CH, *et al*. The Role of the Insulin/IGF System in Cancer: Lessons Learned from Clinical Trials and the Energy Balance-Cancer Link. *Front Endocrinol* 2015;6:77.
128 Renehan AG, Zwahlen M, Minder C, *et al*. Insulin-like growth factor (IGF)-I, IGF binding protein-3, and cancer risk: systematic review and meta-regression analysis. *Lancet* 2004;363:1346–53.
129 Lero MW, Shaw LM. Diversity of insulin and IGF signaling in breast cancer: Implications for therapy. *Mol Cell Endocrinol* 2021;527:111213.
130 Hart PC, Rajab IM, Alebraheem M, *et al*. C-Reactive Protein and Cancer-Diagnostic and Therapeutic Insights. *Front Immunol* 2020;11:595835.
131 Alifano M, Falcoz PE, Seegers V, *et al*. Preresection serum C-reactive protein measurement and survival among patients with resectable non-small cell lung cancer. *J Thorac Cardiovasc Surg* 2011;142:1161–7.
132 Allin KH, Nordestgaard BG, Flyger H, *et al*. Elevated pre-treatment levels of plasma C-reactive protein are associated with poor prognosis after breast cancer: a cohort study. *Breast Cancer Res* 2011;13:R55.
133 Goyal A, Terry MB, Jin Z, *et al*. C-reactive protein and colorectal cancer mortality in U.S. adults. *Cancer Epidemiol Biomarkers Prev* 2014;23:1609–18.
134 Huang Y, Feng JF, Liu JS, *et al*. Prognostic role of serum C-reactive protein in esophageal cancer: a systematic review and meta-analysis. *Ther Clin Risk Manag* 2015;11:89–94.
135 Brown JC, Compton SLE, Meyerhardt JA, *et al*. The dose-response effect of aerobic exercise on inflammation in colon cancer survivors. *Front Oncol* 2023;13:1257767.
136 Li Q, Guo C, Cao B, *et al*. Safety and efficacy evaluation of personalized exercise prescription during chemotherapy for lung cancer patients. *Thorac Cancer* 2024;15:906–18.
137 Ellis M, McIlroy P. Mental handicap nursing. 4. Programmes for progress. *Nurs Mirror* 1985;160:40–3.
138 Pitman A, Suleman S, Hyde N, *et al*. Depression and anxiety in patients with cancer. *BMJ* 2018;361:k1415.
139 Mitchell AJ, Chan M, Bhatti H, *et al*. Prevalence of depression, anxiety, and adjustment disorder in oncological, haematological, and palliative-care settings: a meta-analysis of 94 interview-based studies. *Lancet Oncol* 2011;12:160–74.
140 Forbes H, Carreira H, Funston G, *et al*. Early, medium and long-term mental health in cancer survivors compared with cancer-free comparators: matched cohort study using linked UK electronic health records. *EClinicalMedicine* 2024;76:102826.
141 Yang L, Courneya KS, Friedenreich CM. The Physical Activity and Cancer Control (PACC) framework: update on the evidence, guidelines, and future research priorities. *Br J Cancer* 2024;131:957–69.
142 Van Blarigan EL, Fuchs CS, Niedzwiecki D, *et al*. Association of Survival With Adherence to the American Cancer Society Nutrition and Physical Activity Guidelines for Cancer Survivors After Colon Cancer Diagnosis: The CALGB 89803/Alliance Trial. *JAMA Oncol* 2018;4:783–90.
143 Jones LW, Courneya KS, Mackey JR, *et al*. Cardiopulmonary function and age-related decline across the breast cancer survivorship continuum. *J Clin Oncol* 2012;30:2530–7.
144 West MA, Parry MG, Lythgoe D, *et al*. Cardiopulmonary exercise testing for the prediction of morbidity risk after rectal cancer surgery. *Br J Surg* 2014;101:1166–72.
145 Herrero F, Balmer J, San Juan AF, *et al*. Is cardiorespiratory fitness related to quality of life in survivors of breast cancer? *J Strength Cond Res* 2006;20:535–40.
146 Wood WA, Deal AM, Reeve BB, *et al*. Cardiopulmonary fitness in patients undergoing hematopoietic SCT: a pilot study. *Bone Marrow Transplant* 2013;48:1342–9.
147 Miller KD, Siegel RL, Lin CC, *et al*. Cancer treatment and survivorship statistics, 2016. *CA Cancer J Clin* 2016;66:271–89.
148 Mijwel S, Backman M, Bolam KA, *et al*. Highly favorable physiological responses to concurrent resistance and high-intensity interval training during chemotherapy: the OptiTrain breast cancer trial. *Breast Cancer Res Treat* 2018;169:93–103.
149 Anandavadivelan P, Mijwel S, Wiklander M, *et al*. Five-year follow-up of the OptiTrain trial on concurrent resistance and high-intensity interval training during chemotherapy for patients with breast cancer. *Sci Rep* 2024;14:15333.
150 Winters-Stone KM, Horak F, Dieckmann NF, *et al*. GET FIT: A Randomized Clinical Trial of Tai Ji Quan Versus Strength Training for Fall Prevention After Chemotherapy in Older, Postmenopausal Women Cancer Survivors. *J Clin Oncol* 2023;41:3384–96.
151 Peres J. A Time and Place: The Role of Social Workers in Improving End-of-Life Care. *J Soc Work End Life Palliat Care* 2016;12:185–94.
152 Badaghi N, Buskbjerg C, Kwakkenbos L, *et al*. Positive health outcomes of mindfulness-based interventions for cancer patients and survivors: A systematic review and meta-analysis. *Clin Psychol Rev* 2024;114:102505.