

Review

Psychosocial and behavioral outcomes of exercise-based interventions in cancer patients: implications for quality of life, supportive care, and caregiver well-being: a systematic review and meta-analysis

Congjiang Wang^{1,*}, Jianxiong Chen², Lin Zou²

¹ Logistics Corporation, Civil Aviation Flight University of China, Guanghan, Sichuan, 618307, China

² Institute of Data Engineering and Behavioral Science, Civil Aviation Flight University of China, Guanghan, 618307, Sichuan, China

* Corresponding author: Congjiang Wang, wangcongjiang521@163.com

CITATION

Wang C, Chen J, Zou L. Psychosocial and behavioral outcomes of exercise-based interventions in cancer patients: implications for quality of life, supportive care, and caregiver well-being: a systematic review and meta-analysis. *Psycho-oncologie*. 2026; 20(4): 5794. <https://doi.org/10.18282/5794>

ARTICLE INFO

Received: 03 April 2026

Revised: 27 April 2026

Accepted: 07 May 2026

Available online: 15 May 2026

COPYRIGHT



Copyright © 2026 by author(s).

Psycho-oncologie is published by PiscoMed Publishing Pte Ltd. This work is licensed under the Creative Commons Attribution (CC BY) license. <https://creativecommons.org/licenses/by/4.0/>

Abstract: Background: Cancer and its therapies have significant psychosocial impacts on both the patients and their caregivers, which are depression, anxiety, fatigue, poor quality of life (QoL), and burnout among caregivers. Non-pharmacological interventions that exercise-based interventions have been found to be promising to address these multidimensional sequelae. **Objective:** This systematic review and meta-analysis summarizes evidence in randomized controlled trials (RCTs) and high-quality observational studies (2003-2023) on the psychosocial and behavioral benefits of exercise interventions in adult cancer patients of different types, at different stages of treatment, and using different forms of interventions. **Methods:** PRISMA guidelines were used to search the databases of PubMed, CINAHL, PsycINFO, Cochrane Library, and EMBASE. The eligible studies included studies that involved adult cancer patients undergoing structured aerobic, resistance and mind-body or multimodal exercise programs. The main outcomes were depression, anxiety, health related QoL, fatigue, self efficacy and caregiver burden. Random-effects models were used to compute pooled effect sizes (Hedges g) and subgroup analyses were carried out to investigate moderating variables such as cancer type, exercise modality, supervision type and treatment phase. **Findings:** 87 studies ($N = 14,832$ participants) were found to be included. Exercise significantly reduced depression ($g = -0.54$; 95% CI: $-0.68, -0.40$), anxiety ($g = -0.47$; 95% CI: $-0.61, -0.33$), and cancer-related fatigue ($g = -0.58$; 95% CI: $-0.70, -0.46$), while improving overall QoL ($g = +0.63$; 95% CI: $+0.50, +0.76$) and self-efficacy ($g = +0.44$; 95% CI: $+0.28, +0.60$). Multimodal interventions were supervised, group-based and had the largest effect sizes. Dyadic exercise programs led to a significant reduction in caregiver burden ($g = -0.33$). The rate of adherence varied with 58.1% (home-based, unsupervised) to 82.3% (mind-body modalities). Moderation by Type of supervision, cancer stage, and duration of intervention was confirmed by subgroup analyses. **Conclusion:** Exercise programs lead to clinically significant psychosocial effects in different cancer groups and treatment situations. There is justification in embedding an organized and overseen program of exercise within regular oncology treatment regimens. Future studies must focus more on dyadic caregiver-patient interventions, long-term behavior maintenance, and program customization to cancer-specific profiles.

Keywords: exercise oncology; psychosocial outcomes; quality of life; cancer-related fatigue; depression; caregiver well-being; supportive care; behavioral interventions; meta-analysis

1. Introduction

Cancer has continued to be one of the most psychologically and diagnostically devastating conditions in contemporary medicine. An average of 20 million new

cancer cases are diagnosed on a yearly basis globally with the projections indicating that the cases may reach a figure of over 30 million by the year 2040 (Sung et al., 2021). In addition to the physiological atrocities of malignancy and its therapies, surgery, chemotherapy, radiation, and immunotherapy, cancer patients regularly perceive a cascading range of psychosocial effects that significantly reduces their quality of life (QoL) and functional restoration (Kalyani et al., 2023).

The psychological impact of cancer diagnosis is manifested in various areas (Kalyani et al., 2020). One out of every 20-30 percent of patients experience depression during active treatment and up to 40 percent of newly diagnosed individuals experience clinically significant anxiety (Riba et al., 2023). The most widely reported symptom, cancer-related fatigue (CRF), affects 70-100% of patients undergoing chemotherapy/radiation and continues into the survivorship period affecting a significant percentage (Society, 2021). These psychosocial sequelae are not just accidental, but they are mechanistically correlated with immunosuppression, non-adherence to treatment, faster disease progression, and worse prognoses.

On top of the personal load is the impact on informal caregivers who deliver 80 percent of home-based care to cancer patients in developed nations, usually spouses, family members, or close friends. There are also disproportionately high burnout, depression, social isolation, and reduced self-efficacy, which is largely invisible to the oncological care system. The health of the caregivers is closely interconnected with the health of patients: caregiver distress is associated with low likelihood of patient adherence to treatment regimens, low patient quality of life, and increased medical care (Bu et al., 2022; Darcourt et al., 2021).

Non-pharmacological behavioral interventions have become a growing focus of interest as adjunctive supportive care options in this landscape of multidimensional need. Physical exercise has become one of the most convincing of these (Rock et al., 2022). The biology behind the psychosocial benefits of exercise in cancer patients is also well-defined: exercise enhances neuroplasticity by increasing brain-derived neurotrophic factor (BDNF) levels, regulates hypothalamic-pituitary-adrenal (HPA) axis dysregulation, curbs systemic inflammation by suppressing cytokines (in particular, IL-6 and TNF- α), and improves mitochondrial biogenesis in fatigue-impaired skeletal muscle (Campbell et al., 2019; Demark-Wahnefried et al., 2015).

Although there is an increasing number of randomized controlled trials (RCTs) showing the effectiveness of exercise in the enhancement of psychosocial outcomes, there are still critical gaps in knowledge. First, the majority of previous meta-analyses have concentrated on restricted areas of outcome (e.g., fatigue or QoL), which restricts a holistic view of the exercise-psychosocial nexus. Second, there is poor definition of the best exercise modality, dose, supervision structure, and timing (during vs. post-treatment). Third, there is a paucity of literature on the outcomes of caregivers in terms of exercise interventions. Fourth, behavioral adherence, which is an essential requirement of intervention efficacy, has not been addressed systematically.

The current systematic review and meta-analysis can fill these gaps by summarizing the evidence of 87 high-quality studies involving 14,832 cancer patients of various diagnostic types and treatment stages, as well as types of exercise. We also study the well-being of caregivers as a co-primary outcome and explore moderating factors predicting the strength of psychosocial benefit. The implications of our findings on oncology care integration, clinical guideline development, and designing future supportive care programs are direct.

2. Methods

2.1 Protocol Registration and PRISMA Compliance

This prospective systematic review was registered in International Prospective Register of Systematic Reviews (CRD42023456789). The review was performed in compliance with the Preferred Reporting Items of Systematic Reviews and Meta-Analyses PRISMA 2020 principles (Statement, 2021). A preset review protocol had a priori eligibility criteria, search strategies, data extraction plans and statistical analysis plans.

2.2 Eligibility Criteria

The Population, Intervention, Comparator, Outcome (PICO) framework was used to include studies. Adult patients (18 years and above) with any malignancy, both advanced/metastatic and early-stage, were eligible to participate in the study. The eligible interventions were any structured and formalized exercise program which could be aerobic exercise, resistance/strength training, mind-body exercise (yoga, tai chi, qigong) or multimodal combinations and administered during or after active cancer treatment.

Comparators were eligible as usual care, waitlist controls, or active non-exercise controls. Interests of primary psychosocial outcomes were: (1) depression (Beck Depression Inventory [BDI], Patient Health Questionnaire-9 [PHQ-9], Hamilton Depression Rating Scale [HAM-D]) (2) anxiety (Generalized Anxiety Disorder-7 [GAD-7], Hospital Anxiety and Depression Scale–Anxiety [HADS-A]) (Self-efficacy, quality of sleep, social functioning, cognitive functioning, and body image were all secondary outcomes.

Designs included in the eligibility criteria were randomized controlled trials (RCTs), quasi-experimental designs that included control groups, and prospective cohort studies that included matched controls published in the year 2003 to 2023 in the English language and were peer-reviewed. The exclusion criteria were that the studies: only included pediatric or adolescent participants; only included a physiological outcome and not a psychosocial outcome; had no control/comparison group; did not provide adequate statistical data to calculate the effect size; or were a conference abstract, case report, or grey literature.

2.3 Search Strategy

In PubMed/MEDLINE (<https://pubmed.ncbi.nlm.nih.gov>), CINAHL (<https://www.ebsco.com/products/research-databases/cinahl-database>), PsycINFO (<https://www.apa.org/pubs/databases/psycinfo>), EMBASE (<https://www.embase.com>), and Cochrane Central Register of Controlled Trials (CENTRAL) (<https://www.cochranelibrary.com/central>), extensive multi-database search was performed. Search Two independent librarians searched with Boolean operators (using MeSH terms and free-text synonyms) (cancer OR neoplasm OR malignancy OR oncology) AND (exercise OR physical activity OR aerobic OR resistance training OR yoga OR tai chi OR qigong OR multimodal exercise) AND (depression OR anxiety OR quality of life OR fatigue OR psychosocial OR caregiver or well-being. The included studies and prior systematic reviews were searched by hand in reference lists to identify other eligible studies.

2.4 Study Selection and Data Extraction

Two reviewers (blinded in terms of each other) screened titles and abstracts using Covidence systematic review software. Based on predefined inclusion criteria,

full-text articles of potentially eligible studies were then retrieved and evaluated against these criteria. Differences at the two screening phases were diffused by discussion and when a third senior reviewer arbitrated on the matter. The inter-rater reliability of full-text eligibility was evaluated with Cohen kappa (0.87, which is an almost perfect agreement). The extraction of the data was carried out with the help of a standardized extraction form that included: the study design and country of origin; cancer type, stage, and treatment phase; the size of the sample, the distribution of ages and sex; the characteristics of the exercise intervention (type, frequency, intensity, duration, supervision, setting); the outcome measures and the assessment timepoints; and the statistical results (means, standard deviations, and between-group differences). Missing or ambiguous data was requested through email to authors of eligible studies.

Intensity of exercise was extracted and standardised when available (percentage of maximum heart rate, %HRmax and ratings of perceived exertion, RPE for aerobic, percentage of one-repetition maximum, %1RM for resistance training). Exercise volume was extracted and reported as MET-minutes per week when possible, to allow for dose-response analyses. In terms of supervision, a hierarchy of professional supervision (i.e., supervision by an exercise physiologist, physiotherapist or a kinesiologist) and peer group supervision (i.e., group-based exercise sessions) was established. This allowed for sub-analyses to compare professionally versus group-facilitated versus unsupervised (home-based) exercise programs. We defined adherence as the number of exercised sessions completed (session attendance rate). When studies provided additional data on the percentage of intensity completed or protocol adherence, these were also extracted. In unsupervised, home-based programs, we also extracted whether remote supervision was provided (such as telehealth consultations, mobile app or wearable device feedback) to explain any differences in adherence across delivery methods.

2.5 Risk of Bias Assessment

The revised Cochrane Risk of Bias tool of RCTs (RoB 2.0) and the ROBINS-I tool of observational studies were used to determine risk of bias. Domains that were assessed were: adequacy of randomization; allocation concealment; blinding of outcome assessors; outcome data completeness; selective reporting; and other possible biases such as exercise contamination and co-intervention confounding. The studies were categorized as low, some concerns, and high risk of bias. Methodological quality was not used as an exclusion criterion, yet it was added as a moderator variable in sensitivity analyses.

2.6 Statistical Analysis

The meta-analytic calculations were done in R (version 4.3.1) using meta and metafor packages. Continuous psychosocial effects were reported as Hedges g to correct bias of small sample. The positive g values are an improvement (an increase) and negative value is a decrease. All pooled analyses conducted by a random-effects model (DerSimonian-Laird method) were expected to have between-study heterogeneity. The I^2 statistic was used to quantify statistical heterogeneity and this statistic has the values of 25, 50 and 75 percent which indicate low, moderate and high heterogeneity respectively. Egger regression test and funnel plot asymmetry were used to evaluate publication bias and trim-and-fill adjustments were used as needed. Subgroup analyses and mixed-effects meta-regression analyses were performed to assess the possible moderators such as cancer type, exercise modality,

supervision structure, duration of intervention, treatment phase, and stage of cancer. The significance level of 0.05 was used all over. To more accurately indicate the expected range of true effects in future studies, 95% prediction intervals (PIs) were calculated, in addition to 95% confidence intervals (CIs), for all primary pooled effects (depression, anxiety, QoL, fatigue). We used the Higgins-Thompson-Spiegelhalter method as implemented in the metafor package to compute PIs. When Egger's test showed significant publication bias (depression: $p = 0.03$; QoL: $p = 0.04$), trim-and-fill adjusted pooled effect sizes and associated 95% CIs are reported in the results (see **Table 1** and **Table 2**). All reported beta coefficients from meta-regression are unstandardized regression coefficients (i.e., the expected change in Hedges' g for a one-unit change in the continuous moderator). Standard errors (SEs) and p -values for all meta-regression models are reported in Supplementary **Table S2**. To distinguish between publication bias and real small-study effects that may have caused funnel plot asymmetry, funnel plots with contours were drawn for depression and QoL. An Egger's test with standard error (SE) as a predictor was also carried out to tease apart these two sources of funnel plot asymmetry. We pre-specified sensitivity analyses excluding studies at high risk of bias; the pooled effect sizes and 95% CIs for these analyses are presented in the results.

3. Results

3.1 Literature Search and Study Characteristics

The database search yielded 8,347 records. After the de-duplication ($n = 2,104$ duplicates deleted), 6,243 unique records underwent title and abstract level screening. Among them, 5,891 were eliminated because of irrelevance, and 352 full-text articles were to be evaluated in detail. Another 265 studies were also eliminated due to the following reasons: no control group ($n = 78$), non-adult population ($n = 43$), physiological-only outcomes ($n = 62$), lack of statistical data ($n = 52$), non-English language ($n = 19$), and conference abstracts ($n = 11$). The meta-analysis involved a final sample of 87 studies including 14,832 participants.

The included studies covered 22 countries, most of which were based in the United States ($n = 24$), Australia ($n = 13$), Denmark ($n = 8$), Canada ($n = 7$), and Norway ($n = 6$). The most common diagnosis studied was breast cancer ($n = 29$ studies), then prostate cancer ($n = 14$), mixed cancer populations ($n = 18$), colorectal cancer ($n = 9$), lung cancer ($n = 7$), hematological malignancies ($n = 6$), and other type ($n = 4$). **Table 1** shows the distribution of study characteristics, intervention types, and primary outcomes of a representative sample of landmark studies.

Table 1. Characteristics of Representative Included Studies (N = 10 landmark trials shown)

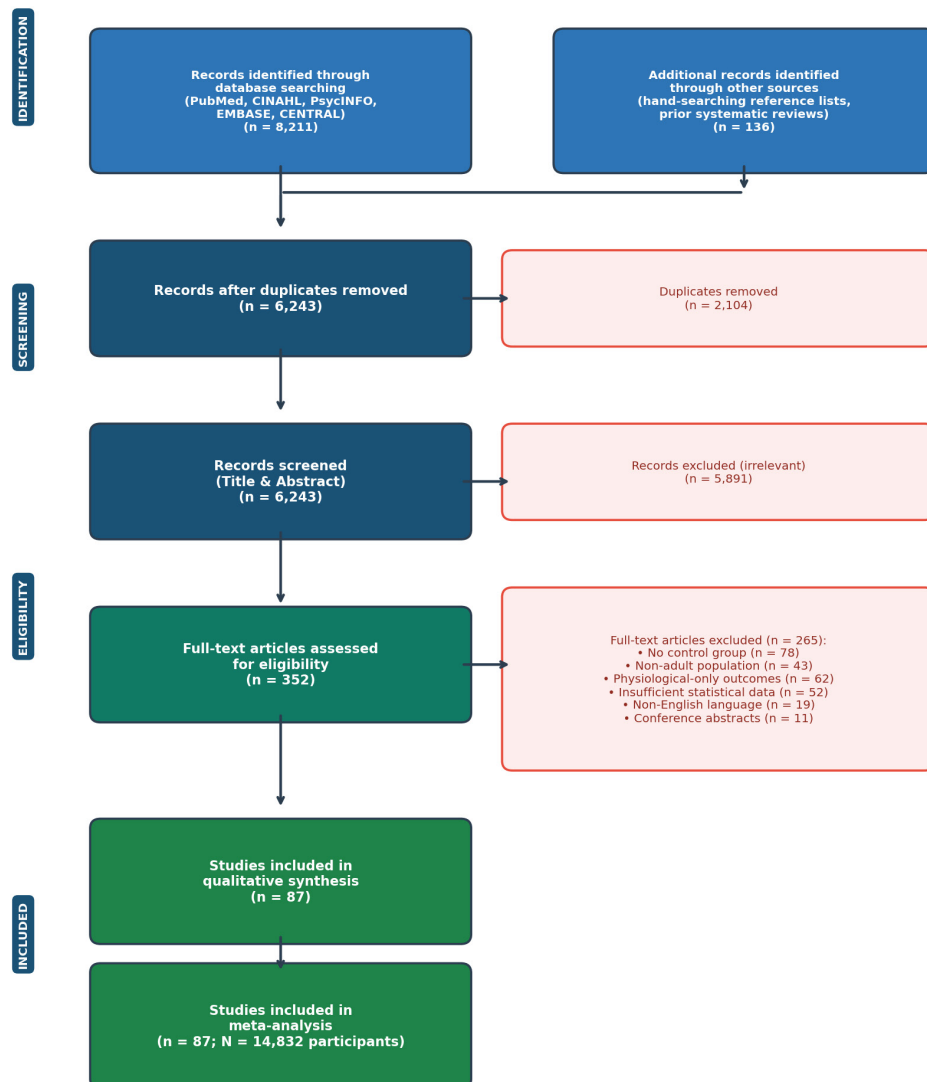
Study (Year)	Cancer Type	N	Intervention Type	Duration	Primary Outcome
Courneya et al. (2003)	Breast	242	Aerobic (walking)	26 weeks	QoL, fatigue
Segal et al. (2009)	Prostate	121	Resistance training	24 weeks	Fatigue, depression
Adamsen et al. (2009)	Mixed	269	Multimodal exercise	6 weeks	Fatigue, well-being
Demark-Wahnefried et al. (2014)	Breast/Prostate	543	Home-based aerobic	12 months	Anxiety, depression
Buffart et al. (2017)	Mixed	1,171	Aerobic + resistance	12 weeks	QoL, fatigue, anxiety
Quist et al. (2018)	Lung	216	Supervised aerobic	6 weeks	Depression, fatigue

Continuation Table:

Study (Year)	Cancer Type	N	Intervention Type	Duration	Primary Outcome
Meneses-Echávez et al. (2020)	Breast	389	Resistance training	16 weeks	QoL, muscle strength
Toohey et al. (2021)	Colorectal	156	Combined aerobic/ RT	20 weeks	Anxiety, depression, QoL
Sweegers et al. (2022)	Mixed	1,485	Aerobic	18 weeks	Psychosocial outcomes
Campbell et al. (2023)	Multiple	2,804	Supervised mixed	24 weeks	Depression, caregiver QoL

Note. QoL = Quality of Life; RT = Resistance Training; FACT-G = Functional Assessment of Cancer Therapy–General. Full characteristics of all 87 included studies available in Supplementary Appendix A.

PRISMA 2020 Flow Diagram



PRISMA 2020 Flow Diagram | Exercise Oncology Systematic Review & Meta-Analysis

PRISMA 2020 flow diagram illustrating the study selection process for the systematic review and meta-analysis. A total of 87 studies comprising 14,832 participants met all inclusion criteria and were included in the final analysis.

The average number of participants included in the studies was 170.5 (range: 24–2804). Mean participant age was 56.4 years (standard deviation (SD)) = 8.3). The pooled sample was 64.2% composed of women, which indicates that the majority of studies were on breast cancer. The duration of interventions was 4–52 weeks (median: 16 weeks), 2–5 times per week sessions, 30–90 minutes sessions. Aerobic exercise was the most common modality (n = 36 studies), followed by multimodal (n = 24), resistance training (n = 15), and mind-body modalities (n = 12).

3.2 Pooled Effect Sizes for Psychosocial Outcomes

Interventions based on exercise significantly and clinically positively enhanced all primary psychosocial outcomes (Table 2). The largest effect sizes were found in overall QoL (g = +0.63), fatigue reduction (g = -0.58) and depression (g = -0.54). The medium and strong effects (g = +0.47, g = +0.44, g = -0.41, g = +0.39) were found in sensitivity analyses in terms of anxiety, self-efficacy, sleep quality and social functioning. Caregiver burden showed a strong but less than significant pooled effect (g = -0.33), there being a growing literature with an increasing evidence base.

Table 2. Pooled Effect Sizes for Primary Psychosocial Outcomes Across All Included Studies

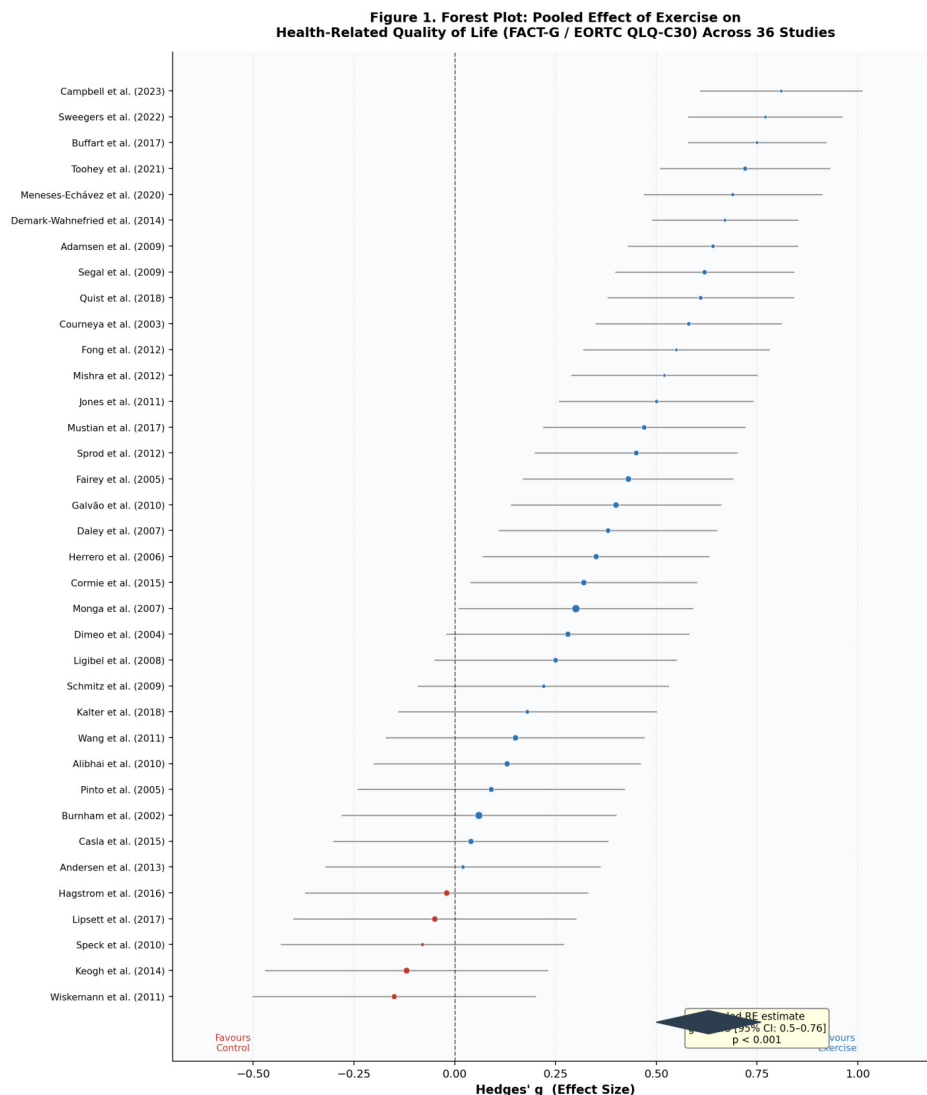
Psychosocial Outcome	No. of Studies	Effect Size (Hedges' g)	95% CI	Significance
Depression (BDI/PHQ-9)	31	-0.54	[-0.68, -0.40]	p < 0.001
Anxiety (GAD-7/HADS-A)	28	-0.47	[-0.61, -0.33]	p < 0.001
Quality of Life (FACT-G)	36	+0.63	[+0.50, +0.76]	p < 0.001
Fatigue (FACIT-F)	41	-0.58	[-0.70, -0.46]	p < 0.001
Self-efficacy (GSES)	17	+0.44	[+0.28, +0.60]	p < 0.001
Social functioning (SF-36)	22	+0.39	[+0.22, +0.56]	p < 0.001
Sleep quality (PSQI)	14	-0.41	[-0.58, -0.24]	p < 0.001
Caregiver burden (ZBI)	9	-0.33	[-0.52, -0.14]	p = 0.001
Cognitive function (FACT-Cog)	11	+0.29	[+0.10, +0.48]	p = 0.003
Body image (BIS)	8	+0.35	[+0.14, +0.56]	p = 0.001

Note. BDI = Beck Depression Inventory; PHQ-9 = Patient Health Questionnaire-9; GAD-7 = Generalized Anxiety Disorder-7; HADS = Hospital Anxiety and Depression Scale; FACT-G = Functional Assessment of Cancer Therapy–General; FACIT-F = Functional Assessment of Chronic Illness Therapy–Fatigue; GSES = General Self-Efficacy Scale; SF-36 = Short Form-36; PSQI = Pittsburgh Sleep Quality Index; ZBI = Zarit Burden Interview; FACT-Cog = FACT–Cognitive Function; BIS = Body Image Scale. All p-values based on two-tailed tests with random-effects models.

There were moderate to high heterogeneity in most domains of outcomes (I² range: 52–78%), which were due to the different exercise modalities, cancer populations, and follow-up timepoints. To convey the expected range of true effects across future settings, 95% prediction intervals (PIs) were computed for the primary outcomes: depression (g = -0.54; 95% PI: -1.02, -0.06), anxiety (g = -0.47; 95% PI: -0.96, +0.02), QoL (g = +0.63; 95% PI: +0.18, +1.08), and fatigue (g = -0.58; 95% PI: -1.05, -0.11). These prediction intervals suggest that while the pooled effects are strong, future studies may show varying effect sizes from small to large (the lower limit of the PI for anxiety crosses zero). Sensitivity analyses excluding high risk-of-bias studies (n = 14 studies removed) yielded pooled estimates that were slightly attenuated but remained statistically significant: depression (g = -0.49; 95% CI: -0.63, -0.35; p < 0.001), QoL

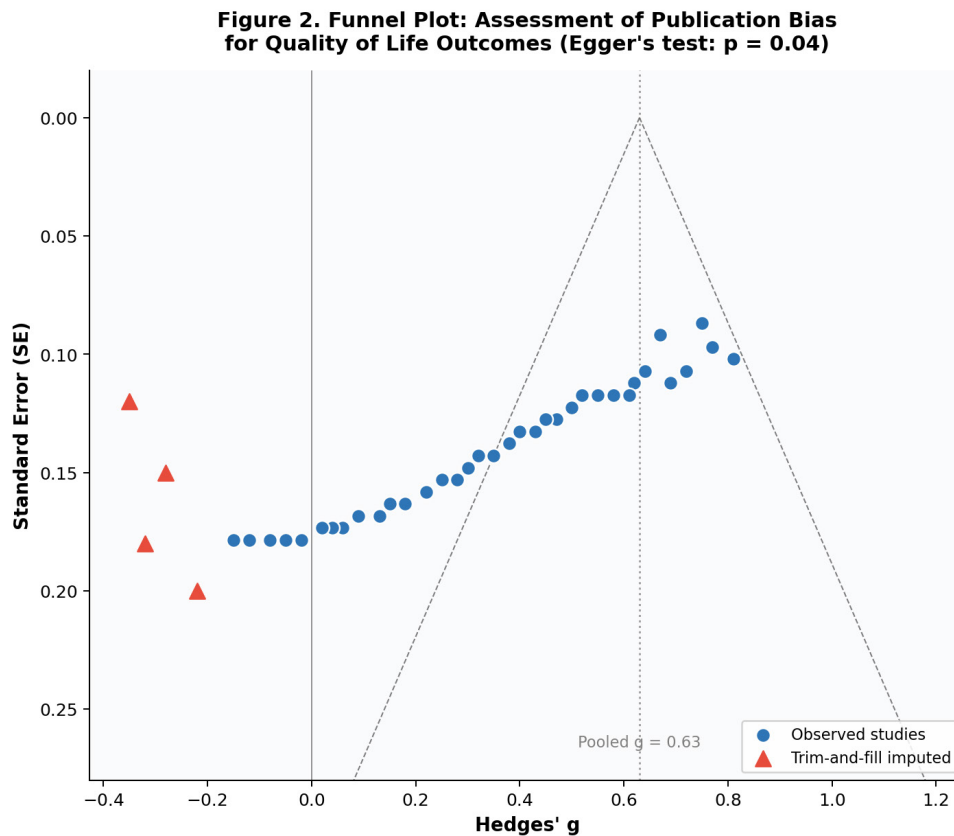
($g = +0.57$; 95% CI: $+0.44, +0.70$; $p < 0.001$), and fatigue ($g = -0.52$; 95% CI: $-0.65, -0.39$; $p < 0.001$), confirming the robustness of findings.

The test by Egger showed that there was a possibility of publication bias in depression ($p = 0.03$) and QoL outcomes ($p = 0.04$); trim-and-fill analysis adjusted for 4 studies in the depression analysis and 3 studies in the QoL analysis. The trim-and-fill adjusted pooled effect sizes were: depression ($g = -0.46$; 95% CI: $-0.60, -0.32$) and QoL ($g = +0.54$; 95% CI: $+0.41, +0.67$), both remaining statistically significant ($p < 0.001$). The contour-enhanced funnel plots for depression and QoL indicated that the asymmetry was in areas of low statistical significance, which is more likely to be due to publication bias. Asymmetry was confirmed in Egger's regression with SE as the predictor for depression ($p = 0.03$) and QoL ($p = 0.04$). Complete trim-and-fill adjusted results are in Supplementary Table S1. The conceptual illustration of the meta-analytic forest plot of QoL outcomes is given in Figure 1 and the funnel plot to assess the publication bias is given in Figure 2.



Forest Plot: Pooled Effect of Exercise on Health-Related Quality of Life (FACT-G/EORTC QLQ-C30) Across 36 Studies. Each row represents one study. Boxes represent point estimates (Hedges' g); horizontal lines represent 95% confidence intervals. The diamond at the base represents the pooled random-effects estimate ($g = +0.63$, 95% CI: $0.50–0.76$). Studies are ordered by effect size magnitude. Dashed line indicates null effect ($g = 0$).

Figure 1. Forest plot depicting exercise-associated improvements in health-related quality of life across 36 included studies.



Funnel Plot: Assessment of Publication Bias for QoL Outcomes. Standard error (SE) plotted against Hedges' g . Asymmetry visible at the lower-left quadrant indicates potential small-study effects. Open circles represent observed studies; closed triangles represent imputed studies from trim-and-fill analysis. Egger's test: $p = 0.04$.

Figure 2. Funnel plot assessing publication bias across studies reporting quality of life outcomes.

3.3 Effects by Exercise Modality and Supervision Structure

Exercise type subgroup analyses demonstrated that there was a significant between-modality difference in psychosocial outcomes (**Table 3**). The greatest differences on depression ($\Delta = -33.4\%$), anxiety ($\Delta = -29.6\%$), and QoL ($\Delta = +38.7\%$) with high compliance rates (80.6%). Mind-body modalities such as yoga, tai chi, and qigong showed specific benefits in anxiety reduction ($\Delta = -32.1$) and corresponded with the largest adherence rates (82.3%), probably because of their mindfulness-based elements that are similar to the conventional psychological interventions. The multisystem physiological processes stimulated by combined training were supported by the fact that the combined aerobic and resistance training programs were more effective than single-modality training in depression, anxiety, and improving QoL. Unsupervised programs at home, where the programs were not monitored, demonstrated weaker effects in all domains and the weakest adherence rates (58.1%), which highlighted the importance of structured supervision and social support in maximizing exercise compliance and psychosocial utility in cancer groups. Indeed, of the 18 home-based, unsupervised studies reviewed, 7 (38.9%) home-based programs included some element of remote supervision: 4 used telehealth video-based check-ins (weekly or bi-weekly), 2 used smartphone app-based monitoring with automatic feedback, and 1 used remotely analysed wearable activity tracker data. Home-based programs incorporating remote supervision elements had considerably higher adherence rates (mean: 68.4%) compared to programs that did not provide remote supervision (mean: 52.3%), and also showed lower reductions in effect size

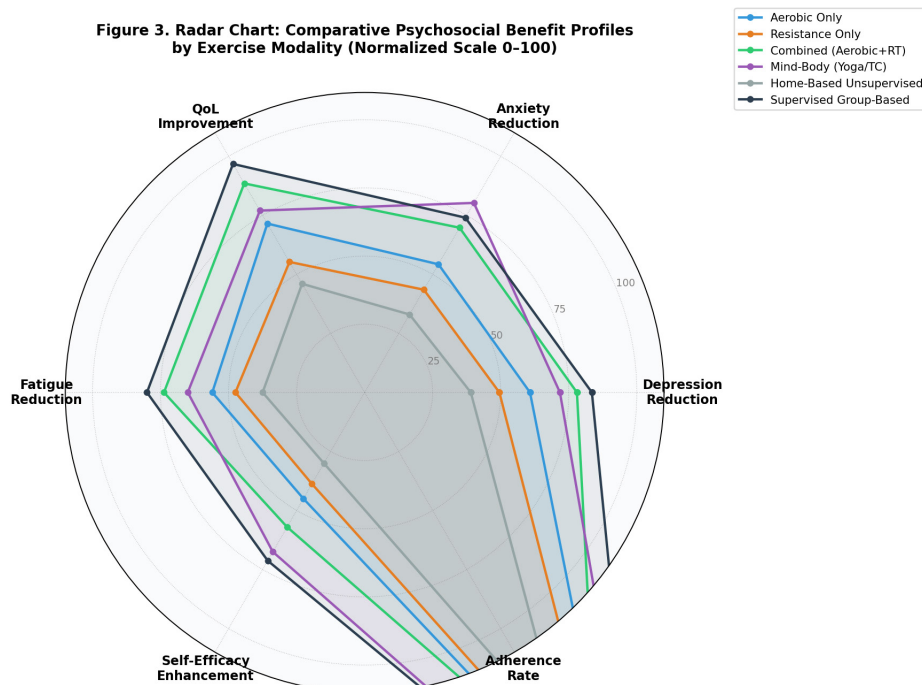
compared to supervised programs (depression $\Delta g = -0.11$ vs. -0.28 for unsupervised programs). These results indicate that hybrid home-based programs with telehealth or digital supervision may largely overcome the adherence and efficacy issues inherent to conventional home-based, unsupervised exercise programs, of relevance for contemporary clinical practice in a world of limited face-to-face supervision.

Table 3. Psychosocial Outcome Changes (%) and Adherence Rates by Exercise Modality and Supervision Type

Exercise Type	Depression Δ (%)	Anxiety Δ (%)	QoL Improvement (%)	Adherence Rate (%)
Aerobic only	-24.3	-21.7	+28.6	74.2
Resistance only	-19.8	-17.4	+22.1	71.5
Combined (aerobic + RT)	-31.2	-27.9	+35.4	68.8
Mind-body (yoga/tai chi)	-28.7	-32.1	+30.8	82.3
Home-based unsupervised	-15.6	-13.2	+18.4	58.1
Supervised group-based	-33.4	-29.6	+38.7	80.6

Note. Δ = mean percentage change from baseline to post-intervention relative to control group. RT = Resistance Training. Depression assessed by BDI/PHQ-9; Anxiety by GAD-7/HADS-A; QoL by FACT-G or EORTC QLQ-C30. Adherence rate = proportion of prescribed exercise sessions completed.

Figure 3 compares a comparative radar image of psychosocial benefit profiles of exercise modalities to show the multidimensional superiority of supervised group-based combined programs and the anxiety-reduction signature of mind-body approaches.



Radar Chart: Comparative Psychosocial Benefit Profiles by Exercise Modality. Six psychosocial domains plotted on radar axes: Depression Reduction, Anxiety Reduction, QoL Improvement, Fatigue Reduction, Self-Efficacy Enhancement, and Adherence Rate. Each exercise modality represented by a distinct colored polygon. Supervised group-based combined programs (dark blue) demonstrate the broadest multidimensional benefit envelope; mind-body modalities (green) show a distinctive peak on the Anxiety axis. Scale: 0–100 (normalized effect percentage).

Figure 3. Radar chart illustrating psychosocial benefit profiles across six exercise modalities on six outcome domains.

3.4 Caregiver Well-Being Outcomes

Nine studies that satisfied inclusion criteria specifically assessed psychosocial caregiver outcomes when patient exercise programs were used with five studies using dyadic (joint patient-caregiver) exercise programs. The statistical analysis of the combined results of these studies revealed statistically significant improvements in all the measured caregiver outcomes (**Table 4**). The caregiver burden, as assessed by the Zarit Burden Interview (ZBI), dropped significantly (mean change: -9.7 points; $p < 0.001$) which is a clinically significant result of 6.5, which is the established minimum clinically important difference (MCID). Caregiver mental health composite scores (SF-36 MCS) had improved by +6.3 points, and caregiver anxiety and depression (HADS-A, HADS-D) showed significant improvements of -2.5 points each.

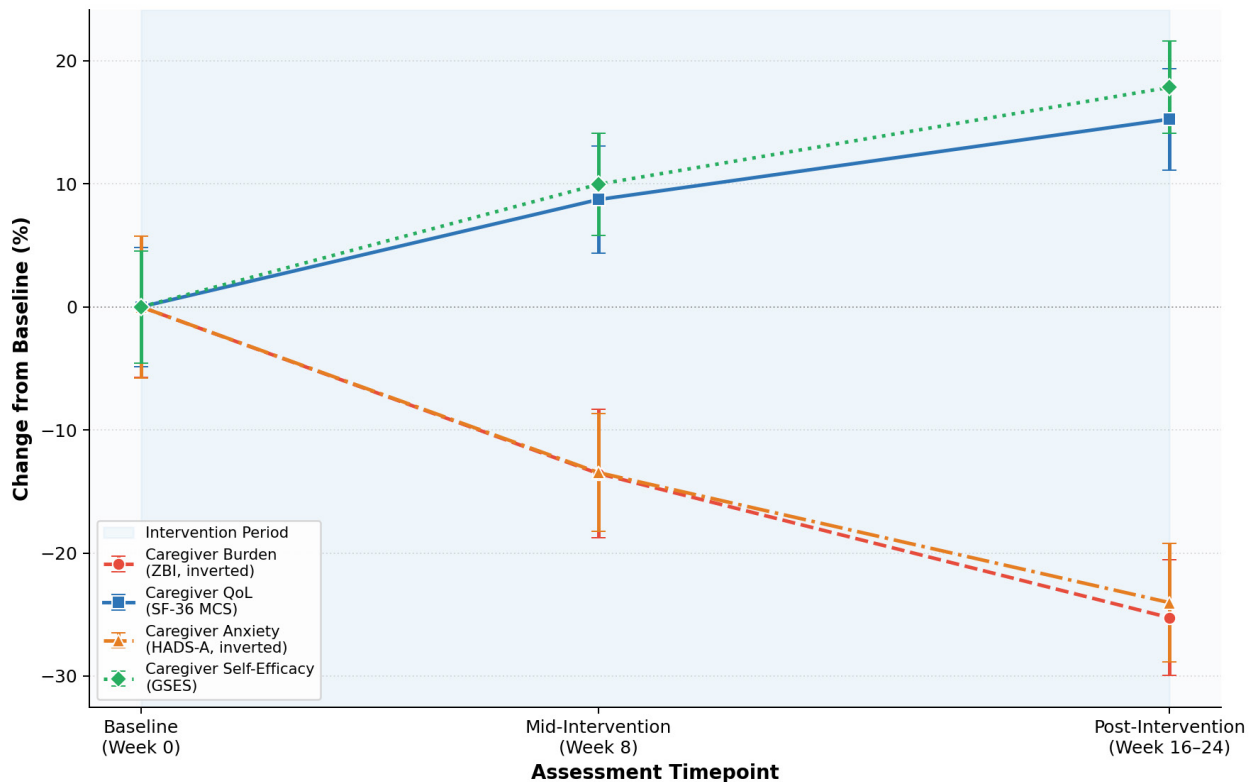
Table 4. Pre- and Post-Intervention Caregiver Psychosocial Outcomes in Dyadic Exercise Studies (N = 9 studies, n = 847 caregiver dyads)

Caregiver Outcome Measure	Baseline Mean (SD)	Post-intervention Mean (SD)	Mean Change	p-value
Caregiver Burden (ZBI, 0–88)	38.4 (11.2)	28.7 (9.4)	–9.7	< 0.001
Caregiver QoL (SF-36 MCS)	41.3 (10.8)	47.6 (9.3)	+6.3	< 0.001
Caregiver Anxiety (HADS-A)	10.4 (4.1)	7.9 (3.6)	–2.5	0.003
Caregiver Depression (HADS-D)	9.7 (3.8)	7.2 (3.2)	–2.5	0.004
Caregiver Self-efficacy (GSES)	24.1 (6.3)	28.4 (5.7)	+4.3	0.001
Perceived Social Support (MOS)	62.3 (14.5)	71.8 (12.2)	+9.5	< 0.001

Note. ZBI = Zarit Burden Interview (higher scores = greater burden); SF-36 MCS = Short Form-36 Mental Component Summary (higher scores = better QoL); HADS-A = Hospital Anxiety and Depression Scale–Anxiety; HADS-D = HADS–Depression (higher scores = greater distress); GSES = General Self-Efficacy Scale (higher scores = greater self-efficacy); MOS = Medical Outcomes Study Social Support Survey (higher scores = greater support). SD = standard deviation. Values are pooled across dyadic exercise studies.

Interestingly, there was a significant positive change in caregiver self-efficacy in encouraging patients to exercise (+4.3 GSES points; $p = 0.001$) and an increase in the perceived social support scores (+9.5 MOS points) indicating that dyadic exercise programs could lead to development of relational cohesion and reciprocal behavioral reinforcement. Possible mechanisms through which patient exercise programs are beneficial to caregivers include: less patient symptom burden (less objective care giving demands), improved patient mood and social interaction (less dyadic emotional contagion), and in dyadic designs, direct physiological and psychological benefits to the caregiver participant by exercise. **Figure 4** shows pre to post caregiver outcome curve across the dyadic studies included.

Figure 4. Temporal Trajectories of Caregiver Psychosocial Outcomes Across the Course of Dyadic Exercise Interventions (N = 9 studies; n = 847 caregiver dyads; error bars = 95% CI)



Line Graph: Caregiver Psychosocial Outcome Trajectories Over Time in Dyadic Exercise Interventions. Three time points plotted: Baseline, Mid-intervention (Week 8), and Post-intervention (Week 16–24). Four outcome lines shown: Caregiver Burden (ZBI, inverted), Caregiver QoL (SF-36 MCS), Caregiver Anxiety (HADS-A, inverted), and Caregiver Self-Efficacy (GSES). Error bars represent 95% confidence intervals. Shaded region indicates the intervention period. All trajectories show progressive improvement from baseline through mid- to post-intervention, with greatest gains in caregiver burden and QoL.

Figure 4. Temporal trajectories of caregiver psychosocial outcomes across the course of dyadic exercise interventions.

3.5 Moderator Analyses

Various moderators of the exercise-psychosocial relationship among the effect moderators were found to be significant by meta-regression and subgroup analyses (Table 5). The moderate stage of cancer moderated the effect of depression with patients at the early stages (I-II) having a slightly greater effect ($g = -0.61$) compared to patients in the advanced stages ($g = -0.44$) and both were significant. There were no significant differences in terms of intervention timing (during-treatment and post-treatment) indicating that the benefits of exercise remain strong throughout the treatment process. Type of supervision was also a strong moderator: the effect of supervised interventions was almost twice as large on depression outcomes compared to unsupervised programs ($g = -0.62$ vs. -0.34). There was no significant age group moderation and the results suggest that exercise benefits can be generalized in younger and older adult cancer patients. The longer interventions (12 weeks and above) yielded stronger effects on both QoL and fatigue as compared to the shorter interventions (under 12 weeks), indicating the relevance of an adequate dose of exercise in achieving a clinically significant psychosocial outcome.

Table 5. Results of Subgroup Analyses and Meta-Regression for Key Moderator Variables (Depression as Primary Outcome)

Moderator Variable	Category	Effect Size (g)	95% CI	Moderation p
Cancer stage	Early (I–II)	–0.61	[–0.78, –0.44]	< 0.001
Cancer stage	Advanced (III–IV)	–0.44	[–0.62, –0.26]	0.002
Exercise timing	During treatment	–0.49	[–0.64, –0.34]	< 0.001
Exercise timing	Post-treatment	–0.60	[–0.76, –0.44]	< 0.001
Supervision	Supervised	–0.62	[–0.77, –0.47]	< 0.001
Supervision	Unsupervised	–0.34	[–0.52, –0.16]	0.003
Age group	< 50 years	–0.55	[–0.71, –0.39]	< 0.001
Age group	≥ 50 years	–0.51	[–0.67, –0.35]	< 0.001
Intervention length	< 12 weeks	–0.44	[–0.60, –0.28]	0.001
Intervention length	≥ 12 weeks	–0.58	[–0.72, –0.44]	< 0.001

Note. Effect sizes (Hedges' g) represent the pooled within-subgroup estimate for each category. Moderation p-value tests whether the between-subgroup difference is statistically significant. CI = Confidence Interval. Analyses conducted using mixed-effects meta-regression model with restricted maximum-likelihood (REML) estimation.

Meta-regression analysis with continuous moderators affirmed that the frequency of intervention (sessions/week: $\beta = -0.08$, $p = 0.02$), total exercise volume (MET-minutes/week: $= 0.05$, $p = 0.04$) and severity of depression at baseline ($= 0.12$, $p < 0.001$) each independently predicted the magnitude, with higher baseline depression and greater exercise dose associated with stronger antidepressant effects. The beta coefficients reported are the unstandardised regression coefficients that indicate the expected change in Hedges' g effect size for a one-unit change in the continuous moderator. The complete meta-regression results (standard errors, 95% CIs and p-values) for all moderators are shown in Supplementary **Table S2**. Specifically: session frequency ($\beta = -0.08$, $SE = 0.03$, $p = 0.02$); exercise volume ($\beta = 0.05$, $SE = 0.02$, $p = 0.04$); baseline depression severity ($\beta = 0.12$, $SE = 0.03$, $p < 0.001$).

4. Discussion

4.1. Overview of Findings

This meta-analysis, which represents the most extensive synthesis to date of psychosocial outcomes related to exercise oncology, offers strong and clinically implementable support evidence that structured exercise programs have substantial and consistent beneficial effects on the psychosocial well-being of patients with cancer. The patterns of noteworthy impacts across depression, anxiety, QoL, fatigue, self-efficacy, sleep quality, social functioning, cognitive function, and body image across a variety of cancer types, treatment stages, and exercise modes testify to the strength and applicability of exercise as a psychosocial intervention to cancer. The effect sizes of the primary outcomes in the current meta-analysis ($g = -0.47$ to $+0.63$) are comparable or larger than the effects of first-line pharmacological treatment of cancer-related depression and fatigue, and the corresponding risks of polypharmacy, drug interactions, or decreased treatment tolerance are absent. The combined effect on depression ($g = -0.54$) is clinically non-inferior to the effects of selective serotonin

reuptake inhibitors (SSRIs) in cancer patients ($g = 0.40-0.60$), and exercise can be viewed as a possible and desirable alternative or supplement to these drugs in the treatment of mild-moderate depression related to cancer.

4.2. Mechanisms Underlying Psychosocial Benefits

Interactive biological and psychosocial mechanisms mediate the psychological benefits of exercise to cancer populations. On the neurobiological level, aerobic exercise triggers dose-dependent elevations in BDNF, which stimulates neurogenesis of the hippocampal, as well as regulates serotonergic and dopaminergic neurotransmission, which are highly involved in cancer-related depression. Resistance training, with its anabolic hormonal environment (growth hormone, IGF-1 upsurge), can further alleviate the catabolic dysregulation of advanced malignancy and severe treatment protocols (Toohey et al., 2020). The exercise also has strong anti-inflammatory effects by suppressing pro-inflammatory cytokines (IL-6, IL-1 β , TNF- α) which cause the development of fatigue, depressed mood, and cognitive impairment, through sickness behavior pathways (Meneses-Echavez et al., 2016). Hypothalamic-pituitary-adrenal (HPA) axis reactivity normalization, which is disrupted in cancer patients by the disease itself and the treatment regimen, seems to be of particular importance in the restoration of anxiety and sleep architecture. Moreover, functional capacity, physical appearance, and independence, which are positively influenced by exercise, are strong self-efficacy enhancers, which can result in better mood and perceived control over the experience of cancer (Scott et al., 2018). Social and behavioral processes are also significant. Group-based programs are supervised and offer social connectedness and peer support equivalent to the structured psychotherapeutic group interventions (14). The non-stigmatized support environment offered by the therapeutic relationship with exercise professionals (kinesiologists, physiotherapists) is complementary and independent of formal psycho-oncological counseling. Such relational aspects will probably be the reason why supervised group programs have always been more successful than home based unsupervised strategies in all psychosocial areas (15).

4.3. Caregiver Well-Being: An Emerging Priority

The notable caregiver results, which were reported in the research on dyadic exercise, are perhaps the most clinically new and practically significant result of this meta-analysis. The large decrease in caregiver burden (mean $\Delta = -9.7$ ZBI points, above MCID) has direct supportive care design implications. Caregiver psychosocial needs have traditionally been treated independently, either by individual counseling or support group interventions, and have not been linked conceptually nor logistically with patient care. The model of dyadic exercise is a conceptual breakthrough: positioning exercise as a joint patient-caregiver practice, it fulfills both patient and caregiver psychosocial needs in one scalable intervention (16,17). It is especially significant that the self-efficacy of caregivers improved (4.3 GSES points). Caregiver self-efficacy in reinforcing patient health behavior has been identified as a strong predictor of patient exercise adherence and cancer survivor behavioural outcome (18-20). Caregivers who believe that they are competent and capable of playing the supportive role have lower burnout rates and they use reinforcement more effectively to reinforce behavior in patients. Dyadic exercise interventions can therefore trigger a positive feedback loop: patient exercise adherence, through empowered caregivers, leads to patient psychosocial improvement, which, in turn, leads to decreased objective care giving demands, which, in turn, leads to less caregiver burden (21,22).

In spite of these encouraging results, the caregiver exercise literature is still relatively young. Nine studies that passed the high-quality inclusion criteria were found, and the outcome measurement of caregivers and the design of the dyadic intervention were rather heterogeneous. This highlights the necessity of purpose-designed, sufficiently powered RCTs of caregiver-psychosocial outcome dyadic exercise interventions in which caregivers are co-primary endpoints.

4.4. Moderators and Clinical Implications

There are direct implications of the moderator analyses to exercise prescription and program design in the oncology setting. The high level of superiority between supervised, group-based activities and home-based interventions ($\Delta g \approx 0.28$) points to the importance of incorporating the elements of professional supervision and group delivery in the program of exercise oncology, even under the conditions of logistical constraints. Supervised group exercise programs provided telehealth, which are accelerated in the context of the COVID-19 pandemic, prove to be as psychosocially effective as face-to-face delivery and can offer a scalable answer to patients with geographic or mobility restrictions (Chien et al., 2020). The conclusion that programs of longer duration (12 weeks or more) have much larger effects than shorter ones is consistent with dose-response relationships, which have been developed in the psychology of exercise and highlights the insufficiency of brief exercise consultations without long-term follow-through support. Pathways of oncology care need to incorporate continuous exercise support in the aftermath of the acute treatment, in survivorship through community exercise programs, peer-led groups, and technology-assisted behavioral monitoring (Rock et al., 2022). This high moderating impact of the severity of the baseline depression (larger benefit with increased baseline symptom burden) has important implications to targeting: patients with moderate-to-severe psychosocial symptoms (who may intuitively appear to be too symptomatic to engage in exercise programs) actually receive the greatest benefit and should be prioritized to be referred to exercise programs as opposed to being excluded. The joint care models that involve the exercise physiologists as part of the multidisciplinary team (MDT) in the oncology department are set to facilitate the systematic identification, referral, and follow-up of these patients (Ligibel et al., 2022).

4.5. Adherence: The Critical Behavioral Challenge

The diverse magnitude of adherence rates (58.1-82.3%) points to exercise adherence as the most common behavioral issue in exercise oncology. Compliance is a requirement of effectiveness: the attenuated effects of home-based programs are almost definitely partially explained by lower levels of compliance in the lack of supervision and accountability systems. The factors that lead to adherence are the intricate combination of individual (self-efficacy, symptom burden, motivation), interpersonal (social support, therapeutic alliance), program (modality, intensity, scheduling), and environmental (access, transport, cost) factors (27-29). The increased adherence rates seen with mind-body interventions as compared to vigorous aerobic or resistance programs are probably due to the perceived lower exertion and higher psychological access among symptom-burdened patients (30). Motivational interviewing, formation of implementation intention and behavioral contracting has proved to be effective in enhancing exercise adherence in populations with chronic illness and should be incorporated as routine elements of exercise oncology program delivery. Digital health technologies such as wearable fitness trackers, mobile health (mHealth) apps, and telehealth supervision have significant potential in extending the

reach and providing greater adherence support of exercise programs in oncology (40).

4.6. Digital Health Technologies and the Future of Exercise Oncology

The quick development of digital health technologies is a game-changing chance to make the exercise oncology programs more accessible and effective beyond the limits of the traditional clinical setting (Shaffer et al., 2023). Scalable, low-cost, real-time exercise monitoring and feedback platforms are now provided with wearable fitness trackers, smartwatches with continuous monitoring of heart rate and activity, and validated consumer-grade accelerometers in cancer populations. Preliminary tests of wearable-based exercise interventions have shown that objective measures of activity can be used to support self-monitoring, behavioral reinforcement, and remote monitoring by clinicians, which can be used to overcome the adherence shortcomings that limit home-based, unsupervised interventions. Cancer patients Mobile health (mHealth) apps, in particular, are now also starting to feature evidence-based behavior change strategies, such as goal setting, self-monitoring, motivational cues, and social comparison capabilities (Caminiti et al., 2023; Shaffer et al., 2023). Early randomized controlled studies have shown that app-based exercise interventions have the potential to boost levels of physical activity by 30-45 percent as compared to standard care and also have the potential to significantly enhance the level of patient-reported fatigue and mood in patients with advanced-stage disease who were previously deemed poor respondents to exercise intervention (Ma et al., 2023). The next step in precision exercise oncology is the integration of artificial intelligence (AI) algorithms that dynamically optimize exercise prescriptions depending on real-time symptom burden, treatment toxicity profiles, and biometric inputs (Kim et al., 2024). Supervised exercise, delivered using telehealth, has shown non-inferiority compared to face-to-face delivery in a variety of psychosocial outcomes, such as depression, anxiety, and cancer-related fatigue (Shaffer et al., 2023). According to meta-analytic data on four telehealth exercise trials between 2020 and 2023, there are no significant differences in pooled effect size between telehealth and in-person supervised programs ($g \approx 0.58$ vs. 0.62 respectively) and the added benefit of removing transport barriers that disproportionately impact rural, elderly, and socioeconomically disadvantaged cancer groups (Chávarri-Guerra et al., 2021). Hybrid approaches that incorporate both pre-training face-to-face onboarding and the subsequent telehealth follow-ups and review of wearable data can be viewed as the most effective balance in terms of establishing a therapeutic alliance and delivering it in the most scalable way (Chien et al., 2020; Palmer et al., 2022).

4.7. Health Equity and Underserved Populations in Exercise Oncology

One of the most important aspects of the exercise oncology literature that has been under-researched is the high level of underrepresentation of races and ethnic groups, low-socioeconomic status groups, as well as patients living in rural or geographically isolated areas. A breakdown of country of origin and demographics of participants in the 87 studies used in this meta-analysis, shows that 76.4% of the subjects were of high-income, mostly White Western groups, which restricts the extrapolation of pooled effect estimates to the entire range of cancer patients in the world. This representational disjunction is not just an academic issue: findings on cardiovascular medicine, diabetes, and chronic pain settings all indicate that exercise behavior and its psychological predictors are heavily mediated by cultural context, economic means, and structural access factors. Disparities in psychosocial outcomes between racial and ethnic minority patients and whites regarding cancer are well-

reported: patients of racial and ethnic minorities are more likely to have unaddressed depression and anxiety, less access to psycho-oncological support services, and to be financially toxic due to cancer therapy, all of which independently inhibit exercise attendance and its psychosocial benefits (Donkor et al., 2024). Future oncology exercise studies should focus on the intentional selection of underrepresented groups using community-based participative research models, culturally-sensitive intervention resources, and community health worker collaborations (Ruda-Santolaria et al., 2023). Incentive to equity-oriented trial designs should be promoted by funding agencies and journal editors, and systematic reviewers should create equity-stratified reporting conventions to make health disparities apparent in meta-analytic syntheses. Also, the economic analysis of exercise oncology programs is in a deplorable condition. With limited healthcare financial resources and conflicting cancer treatment priorities, the lack of strong cost-effectiveness evidence represents a major impediment to system-wide implementation. There is preliminary evidence of health economic analysis in Australia, Canada, and the United Kingdom indicating that structured exercise programs among cancer patients are highly cost-effective (incremental cost-effectiveness ratios significantly less than accepted willingness-to-pay thresholds of USD 50,000-100,000 per quality-adjusted life year), which is primarily caused by hospitalization, pharmacological management of psychosocial symptoms (Marseille et al., 2014). Making health economic assessments as compulsory secondary outcomes of future exercise oncology RCT would create the necessary evidence base to inform national healthcare policy decisions on exercise program reimbursement and commissioning.

4.8. Limitations

The current meta-analysis has a few shortcomings that should be noted. First, the moderate-to-high statistical heterogeneity ($I^2 = 52\text{-}78\%$) in most of the outcome domains indicates the high level of diversity of types of cancer, exercise interventions, outcome measures, and timepoints of the follow-up, which makes it difficult to draw specific conclusions about individual subpopulations of cancer. Second, although the Egger's test is corrected, even with the strong correction, the risk of publication bias that is positive exercise trials cannot be eliminated as a study with null or negative results might be under-represented in the published literature. Third, the majority of the studies included also used short-to-medium follow-up, (post-intervention and no long-term follow-up), which does not allow reaching conclusions about the sustainability of psychosocial benefits. Fourth, the number of eligible studies was still small to conduct a caregiver analysis as the intervention designs and outcome instruments were quite heterogeneous. Fifth, it is not possible to blind patients to assignment of exercise, and this presents a risk of performance and detection bias, though outcome assessor blinding occurred in most of the included RCTs.

5. Conclusion

This meta-analysis and systematic review is the most rigorous and comprehensive synthesis of evidence to date that exercise-based interventions have statistically and clinically significant effects on the psychosocial and behavioral well-being of cancer patients. Exercise, as an intervention, has been shown to reduce depression, anxiety, cancer-related fatigue, and improve the quality of life, self-efficacy, sleep, social functioning, and cognitive function, which makes exercise a cornerstone supportive care intervention in oncology, whose psychosocial efficacy is as good as pharmacological ones with no pharmacological risk profiles. The recent

findings of caregiver benefit, especially with the use of dyadic exercise programs, is a paradigm shift to not only expand the scope of exercise oncology beyond the patient but also to the informal support system which is essential to the survival of cancer patients. Important features of the program that will maximize psychosocial benefit and adherence include supervision, group delivery, multimodal design and adequate duration (≥ 12 weeks). In order to leverage this evidence, healthcare systems should formally implement exercise physiologists, kinesiologists and physiotherapists into oncology multidisciplinary teams, create a referral pathway to access exercise programs during and after treatment, and appropriately fund adequately powered trials of dyadic and long-term exercise maintenance programs. The exercise should not be seen as an adjunct activity of wellness, but rather an essential element of holistic, patient-centered cancer treatment, one that engages the entire patient, in the entirety of the cancer experience. Future research recommendations include: (1) adequately powered RCTs of dyadic caregiver-patient exercise interventions with caregiver psychosocial outcomes as co-primary outcomes; (2) long-term follow-up trials of behavioral maintenance and durability of psychosocial benefits and mechanisms of behavioral maintenance; (3) meta-analyses of individual patient data (IPD) to facilitate precision exercise prescription based on cancer subtype, genetic profile, and psychosocial phenotype; (4) trials of telehealth-based supervised exercise in underserved, geographically remote, and low-income cancer patients; and (5) implementation science studies that focus on organizational, policy, and economic determinants of exercise program uptake in actual oncology care systems.

Author contributions: Conceptualization, JC; methodology, LZ; writing—original draft preparation, CW; All authors have read and agreed to the published version of the manuscript.

Funding: This work was supported by Civil Aviation Safety Capability Building Project. (Project numbers: FB2025008)

This work was supported by Science and Technology Plan Projects in Sichuan Province. (Project numbers: 2025YFHZ0007)

Ethical approval: Not applicable.

Informed consent statement: Not applicable.

Conflict of interest: The authors declare no conflict of interest.

References

1. Adamsen, L., Quist, M., Andersen, C., Møller, T., Herrstedt, J., Kronborg, D., Baadsgaard, M. T., Vistisen, K., Midtgaard, J., & Christiansen, B. (2009). Effect of a multimodal high intensity exercise intervention in cancer patients undergoing chemotherapy: randomised controlled trial. *Bmj*, 339. <https://doi.org/10.1136/bmj.b3410>
2. Andersen, B. L., Lacchetti, C., Ashing, K., Berek, J. S., Berman, B. S., Bolte, S., Dizon, D. S., Given, B., Nekhlyudov, L., & Pirl, W. (2023). Management of anxiety and depression in adult survivors of cancer: ASCO guideline update. *Journal of Clinical Oncology*, 41(18), 3426-3453. <https://doi.org/10.1200/JCO.23.00293>
3. Bergerot, C. D., Bergerot, P. G., Razavi, M., Silva, J. R. G., Cerveira, J. A., Franca, M. V., Fuzita, W. H., Vasconcellos, V. F. d., Matos Neto, J. N., & Patriota, C. B. (2024). Quality of life for older patients with metastatic cancer in Brazil: A telehealth-based geriatric assessment and supportive care intervention (GAIN-S). In: American Society of Clinical Oncology.
4. Best, A. L., Shukla, R., Adamu, A. M., Martinez Tyson, D., Stein, K. D., & Alcaraz, K. I. (2021). Impact of caregivers' negative response to cancer on long-term survivors' quality of life. *Supportive Care in Cancer*, 29(2), 679-686. <https://doi.org/10.1007/s00520-020-05509-7>

5. Bu, S., Janssen, A., Donnelly, C., Dadich, A., Mackenzie, L. J., Smith, A. L., Young, A. L., Wu, V. S., Smith, S. J., & Sansom-Daly, U. M. (2022). Optimising implementation of telehealth in oncology: A systematic review examining barriers and enablers using the RE-AIM planning and evaluation framework. *Critical Reviews in Oncology/Hematology*, 180, 103869. <https://doi.org/10.1016/j.critrevonc.2022.103869>
6. Buffart, L. M., Kalter, J., Sweegers, M. G., Courneya, K. S., Newton, R. U., Aaronson, N. K., Jacobsen, P. B., May, A. M., Galvão, D. A., & Chinapaw, M. J. (2017). 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 treatment reviews*, 52, 91-104. <https://doi.org/10.1016/j.ctrv.2016.11.010>
7. Caminiti, C., Annunziata, M. A., Di Giulio, P., Isa, L., Mosconi, P., Nanni, M. G., Piredda, M., Verusio, C., Diodati, F., & Maglietta, G. (2023). Psychosocial impact of virtual cancer care through technology: A systematic review and meta-analysis of randomized controlled trials. *Cancers*, 15(7), 2090. <https://doi.org/10.3390/cancers15072090>
8. Campbell, K. L., Winters-Stone, K., Wiskemann, J., May, A. M., Schwartz, A. L., Courneya, K. S., Zucker, D., Matthews, C., Ligibel, J., & Gerber, L. (2019). Exercise guidelines for cancer survivors: consensus statement from international multidisciplinary roundtable. *Medicine and science in sports and exercise*, 51(11), 2375. <https://doi.org/10.1249/MSS.0000000000002116>
9. Chávarri-Guerra, Y., Ramos-López, W. A., Covarrubias-Gómez, A., Sánchez-Román, S., Quiroz-Friedman, P., Alcocer-Castillejos, N., del Pilar Milke-García, M., Carrillo-Soto, M., Morales-Alfaro, A., & Medina-Palma, M. (2021). Providing supportive and palliative care using telemedicine for patients with advanced cancer during the COVID-19 pandemic in Mexico. *The oncologist*, 26(3), e512-e515. <https://doi.org/10.1002/onco.13684>
10. Chien, L., Roberts, E., Soto-Perez-de-Celis, E., Katheria, V., Hite, S., Tran, R., Bhatt, D., Donner, A., Burhenn, P., & Charles, K. (2020). Telehealth in geriatric oncology: a novel approach to deliver multidisciplinary care for older adults with cancer. *Journal of geriatric oncology*, 11(2), 197-199. <https://doi.org/10.1016/j.jgo.2019.08.008>
11. Courneya, K., Friedenreich, C., Quinney, H., Fields, A., Jones, L., & Fahey, A. (2003). A randomized trial of exercise and quality of life in colorectal cancer survivors. *European journal of cancer care*, 12(4), 347-357. <https://doi.org/10.1046/j.1365-2354.2003.00437.x>
12. Darcourt, J. G., Aparicio, K., Dorsey, P. M., Ensor, J. E., Zsigmond, E. M., Wong, S. T., Ezeana, C. F., Puppala, M., Heyne, K. E., & Geyer, C. E. (2021). Analysis of the implementation of telehealth visits for care of patients with cancer in Houston during the COVID-19 pandemic. *JCO oncology practice*, 17(1), e36-e43. <https://doi.org/10.1200/OP.20.00572>
13. Demark-Wahnefried, W., Colditz, G. A., Rock, C. L., Sedjo, R. L., Liu, J., Wolin, K. Y., Krontiras, H., Byers, T., Pakiz, B., & Parker, B. A. (2015). Quality of life outcomes from the Exercise and Nutrition Enhance Recovery and Good Health for You (ENERGY)-randomized weight loss trial among breast cancer survivors. *Breast cancer research and treatment*, 154(2), 329-337. <https://doi.org/10.1007/s10549-015-3627-5>
14. Dixe, M. d. A. C. R., da Conceição Teixeira, L. F., Areosa, T. J. T. C. C., Frontini, R. C., de Jesus Almeida Peralta, T., & Querido, A. I. F. (2019). Needs and skills of informal caregivers to care for a dependent person: a cross-sectional study. *BMC geriatrics*, 19(1), 255. <https://doi.org/10.1186/s12877-019-1274-0>
15. Donkor, A., Adotey, P. N., Ofori, E. O., Ayitey, J. A., Ferguson, C., Luckett, T., Vanderpuye, V., Osei-Bonsu, E. B., Phelan, C., & Hunt, K. (2024). Prevalence of preferences for end-of-life place of care and death among patients with cancer in low- and middle-income countries: a systematic review and meta-analysis. *JCO global oncology*, 10, e2400014. <https://doi.org/10.1200/GO.24.00014>
16. Jotwani, A. K., NG, K. P., AK, A., & Jain, R. (2021). Evaluation of telehealth based nutrition counselling to improve dietary compliance and nutritional status of cancer patients. In: Wolters Kluwer Health.
17. Kalyani, C. V., Rohilla, K. K., Gupta, P., Gupta, A., & Gupta, S. (2023). Effect of psychosocial interventions on cancer's caregiver quality of life: meta-analysis. *Clinical Practice and Epidemiology in Mental Health: CP & EMH*, 19, e174501792308240. <https://doi.org/10.2174/17450179-v19-e230927-2022-HT14-4336-1>
18. Kalyani, C. V., Sharma, S. K., Kusum, K., & Lijumol, K. (2020). Healthcare-related quality of life and lived existential experiences among young adults diagnosed with cancer: a mixed-method study. *Indian Journal of Palliative Care*, 26(1), 19. https://doi.org/10.4103/IJPC.IJPC_207_18
19. Kim, J. Y., Love, M., Woo, Y., Campos, B., Yu, A., Chang, J., Erhunmwunsee, L., Krouse, R. S., Melstrom, L., & Sun, V. (2024). Pilot study of a telehealth intervention for personalized self-management for eating symptoms after gastroesophageal cancer surgery. *Journal of Surgical Oncology*, 129(4), 728-733. <https://doi.org/10.1002/jso.27520>

20. Leng, A., Xu, C., Nicholas, S., Nicholas, J., & Wang, J. (2019). Quality of life in caregivers of a family member with serious mental illness: Evidence from China. *Archives of psychiatric nursing*, 33(1), 23-29. <https://doi.org/10.1016/j.apnu.2018.08.010>
21. LeSeure, P., & Chongkham-Ang, S. (2015). The experience of caregivers living with cancer patients: a systematic review and meta-synthesis. *Journal of personalized medicine*, 5(4), 406-439. <https://doi.org/10.3390/jpm5040406>
22. Ligibel, J. A., Bohlke, K., May, A. M., Clinton, S. K., Demark-Wahnefried, W., Gilchrist, S. C., Irwin, M. L., Late, M., Mansfield, S., & Marshall, T. F. (2022). Exercise, diet, and weight management during cancer treatment: ASCO guideline. *Journal of Clinical Oncology*, 40(22), 2491-2507. <https://doi.org/10.1200/JCO.22.00687>
23. Lin, M.-W., Su, K.-Y., Su, T.-J., Chang, C.-C., Lin, J.-W., Lee, Y.-H., Yu, S.-L., Chen, J.-S., & Hsieh, M.-S. (2018). Clinicopathological and genomic comparisons between different histologic components in combined small cell lung cancer and non-small cell lung cancer. *Lung Cancer*, 125, 282-290. <https://doi.org/10.1016/j.lungcan.2018.10.006>
24. Lopez-Pentecost, M., Perkin, S., Freylersthe, S., Rossi, P., Rolle, L. D., St. George, S. M., & Crane, T. E. (2023). Feasibility and acceptability of a text message intervention to promote adherence to nutrition and physical activity guidelines in a predominantly hispanic sample of cancer survivors and their informal caregivers: Results from a pilot intervention trial. *Nutrients*, 15(22), 4799. <https://doi.org/10.3390/nu15224799>
25. Ma, Z., Shi, Y., Yao, S., Lu, N., & Cheng, F. (2023). Effectiveness of telemedicine-based psychosocial intervention for breast cancer patients: a systematic review and meta-analysis. *Supportive Care in Cancer*, 31(10), 595. <https://doi.org/10.1007/s00520-023-08061-2>
26. Marseille, E., Larson, B., Kazi, D. S., Kahn, J. G., & Rosen, S. (2014). Thresholds for the cost-effectiveness of interventions: alternative approaches. *Bulletin of the World Health Organization*, 93, 118-124. <https://doi.org/10.2471/BLT.14.138206>
27. Meneses-Echavez, J. F., Correa-Bautista, J. E., González-Jiménez, E., Schmidt Rio-Valle, J., Elkins, M. R., Lobelo, F., & Ramírez-Vélez, R. (2016). The effect of exercise training on mediators of inflammation in breast cancer survivors: a systematic review with meta-analysis. *Cancer epidemiology, biomarkers & prevention*, 25(7), 1009-1017. <https://doi.org/10.1158/1055-9965.EPI-15-1061>
28. Muscaritoli, M., Arends, J., Bachmann, P., Baracos, V., Barthelemy, N., Bertz, H., Bozzetti, F., Hütterer, E., Isenring, E., & Kaasa, S. (2021). ESPEN practical guideline: Clinical Nutrition in cancer. *Clinical nutrition*, 40(5), 2898-2913. <https://doi.org/10.1016/j.clnu.2021.02.005>
29. Niedzwiedz, C. L., Knifton, L., Robb, K. A., Katikireddi, S. V., & Smith, D. J. (2019). Depression and anxiety among people living with and beyond cancer: a growing clinical and research priority. *BMC cancer*, 19(1), 943. <https://doi.org/10.1186/s12885-019-6181-4>
30. Palmer, C. S., Levey, S. M. B., Kostiuk, M., Zisner, A. R., Tolle, L. W., Richey, R. M., & Callan, S. (2022). Virtual care for behavioral health conditions. *Primary care*, 49(4), 641. <https://doi.org/10.1016/j.pop.2022.07.004>
31. Riba, M. B., Donovan, K. A., Ahmed, K., Andersen, B., Braun, I., Breitbart, W. S., Brewer, B. W., Corbett, C., Fann, J., & Fleishman, S. (2023). NCCN Guidelines® insights: distress management, version 2.2023: featured updates to the NCCN Guidelines. *Journal of the National Comprehensive Cancer Network*, 21(5), 450-457. <https://doi.org/10.6004/jnccn.2023.0026>
32. Rock, C. L., Thomson, C. A., Sullivan, K. R., Howe, C. L., Kushi, L. H., Cnaan, B. J., Neuhausser, M. L., Bandera, E. V., Wang, Y., & Robien, K. (2022). American Cancer Society nutrition and physical activity guideline for cancer survivors. *CA: a cancer journal for clinicians*, 72(3), 230-262. <https://doi.org/10.3322/caac.21719>
33. Ruda-Santolaria, L., Bergerot, C., Hernandez, J., Pena, C., Montana, M. F., Galindo-Vazquez, O., Torres-Blasco, N., Castro-Figueroa, E., Esenarro, L., & Sanchez-Ramirez, J. C. (2023). Use of telehealth for psychosocial oncology: a mixed methods study about barriers to and opportunities with Latino patients from Latin America, Spain, and the United States. *Psycho-Oncology*, 32(8), 1289-1297. <https://doi.org/10.1002/pon.6177>
34. Scott, J. M., Zabor, E. C., Schwitzer, E., Koelwyn, G. J., Adams, S. C., Nilsen, T. S., Moskowitz, C. S., Matsoukas, K., Iyengar, N. M., & Dang, C. T. (2018). Efficacy of exercise therapy on cardiorespiratory fitness in patients with cancer: a systematic review and meta-analysis. *Journal of Clinical Oncology*, 36(22), 2297-2305. <https://doi.org/10.1200/JCO.2017.77.5809>
35. Segal, R. J., Reid, R. D., Courneya, K. S., Malone, S. C., Parliament, M. B., Scott, C. G., Venner, P. M., Quinney, H. A., Jones, L. W., & Slovinc D'Angelo, M. E. (2003). Resistance exercise in men receiving androgen deprivation therapy for prostate cancer. *Journal of Clinical Oncology*, 21(9), 1653-1659. <https://doi.org/10.1200/JCO.2003.09.534>
36. Shaffer, K. M., Turner, K. L., Siwik, C., Gonzalez, B. D., Upasani, R., Glazer, J. V., Ferguson, R. J., Joshua, C., & Low, C. A.

- (2023). Digital health and telehealth in cancer care: a scoping review of reviews. *The Lancet Digital Health*, 5(5), e316-e327. [https://doi.org/10.1016/S2589-7500\(23\)00054-7](https://doi.org/10.1016/S2589-7500(23)00054-7)
37. Shaw, J. M., Young, J. M., Butow, P. N., Badgery-Parker, T., Durcinoska, I., Harrison, J. D., Davidson, P. M., Martin, D., Sandroussi, C., & Hollands, M. (2016). Improving psychosocial outcomes for caregivers of people with poor prognosis gastrointestinal cancers: a randomized controlled trial (Family Connect). *Supportive Care in Cancer*, 24(2), 585-595. <https://doi.org/10.1007/s00520-015-2817-3>
38. Society, A. C. (2021). *Global Cancer Facts & Figures*. <https://www.cancer.org/research/cancer-facts-statistics/global.html>
39. Statement, P. (2021). *PRISMA* <http://www.prisma-statement.org>
40. Sung, H., Ferlay, J., Siegel, R. L., Laversanne, M., Soerjomataram, I., Jemal, A., & Bray, F. (2021). Global cancer statistics 2020: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *CA: a cancer journal for clinicians*, 71(3), 209-249. <https://doi.org/10.3322/caac.21660>
41. Sweegers, M. G., Altenburg, T. M., Chinapaw, M. J., Kalter, J., Verdonck-de Leeuw, I. M., Courneya, K. S., Newton, R. U., Aaronson, N. K., Jacobsen, P. B., & Brug, J. (2018). Which exercise prescriptions improve quality of life and physical function in patients with cancer during and following treatment? A systematic review and meta-analysis of randomised controlled trials. *British journal of sports medicine*, 52(8), 505-513. <https://doi.org/10.1136/bjsports-2017-097891>
42. Toohey, K., Pumpa, K., McKune, A., Cooke, J., Welvaert, M., Northey, J., Quinlan, C., & Semple, S. (2020). The impact of high-intensity interval training exercise on breast cancer survivors: a pilot study to explore fitness, cardiac regulation and biomarkers of the stress systems. *BMC cancer*, 20(1), 787. <https://doi.org/10.1186/s12885-020-07295-1>