

Article

Tai Chi intervention and its impact on anxiety, depression, and quality of life in oncology patients

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Abstract: Tai Chi has emerged as a promising therapeutic exercise within sport and exercise oncology, integrating physical conditioning with psychophysiological regulation to support cancer recovery. This systematic review and partial meta-analysis examined twelve cancer-specific quantitative studies investigating Tai Chi's effects on anxiety, depression, fatigue, and quality of life (QoL) in cancer patients. Where sufficient homogeneous data were available, random-effects meta-analysis was performed; for outcomes where measurement heterogeneity precluded pooling, a structured narrative synthesis was conducted following the SWiM reporting guideline. Meta-analysis of four RCTs yielded a pooled standardized mean difference of 0.69 (95% CI 0.44–0.95, $I^2 = 28\%$) favoring Tai Chi over control conditions for global QoL. Narrative synthesis of anxiety and depression outcomes indicated consistent directional benefits across trials, with individual effect sizes in the small-to-moderate range. Mechanistic evidence from included trials suggested concurrent reductions in cortisol, interleukin-6 (IL-6), and C-reactive protein (CRP), as well as enhanced heart-rate variability, consistent with proposed autonomic and immune pathways; however, only one trial conducted formal mediation analysis, and causal links remain to be confirmed. Preliminary comparative evidence suggests that Tai Chi may achieve similar or potentially favorable improvements in emotional well-being compared with conventional exercise through its dual emphasis on mindfulness and controlled movement, although direct head-to-head trials remain limited. From a sport-science perspective, Tai Chi operates as a mind–body neuromotor training system that may foster both physical and psychological resilience. It represents a safe, low-impact, and culturally adaptable intervention suitable for diverse cancer populations and treatment phases. Future large-scale, mechanism-driven randomized controlled trials are needed to define optimal training parameters, dose–response relationships, and long-term physiological adaptations underlying Tai Chi's potential integrative therapeutic.

Keywords: anxiety; cancer rehabilitation; mind-body exercise; psychoneuro immunology; quality of life; Tai Chi effects in oncology rehabilitation

1. Introduction

1.1. Background

Cancer remains a major global health burden with substantial psychological sequelae that can persist across the cancer trajectory. Contemporary psycho-oncology emphasizes the integration of psychological, physical, and social well-being with disease management to optimize overall outcomes [1]. Systematic syntheses in cancer populations have noted variability in how Tai Chi and other mind-body practices

influence quality of life (QoL), anxiety, and depression, but overall patterns suggest potential benefits, particularly for cancer-related fatigue and psychosocial well-being in some settings [2,3]. The integrative care perspective is further underscored by guidelines that explicitly define symptom management, including anxiety and depression, as core components of comprehensive cancer care [1], and by evidence maps that chart the breadth of Tai Chi's health effects across populations, including cancer survivors [4]. Together, these sources support a rationale for evaluating Tai Chi as a component of holistic cancer rehabilitation that addresses emotional and social functioning in addition to physical recovery.

However, the existing evidence base is characterized by considerable methodological heterogeneity, including variation in Tai Chi styles, intervention durations, outcome instruments, and study designs, which complicates the synthesis and interpretation of findings across studies [5,6]. These challenges highlight the need for systematic approaches that transparently distinguish between outcomes amenable to quantitative pooling and those requiring narrative synthesis [7].

1.2. Tai Chi as a mind-body intervention

Tai Chi is a slow, meditative movement practice that combines breath regulation, structured attention, and fluid motor sequences, yielding improvements in balance, flexibility, and autonomic regulation. Foundational reviews describe Tai Chi as a mind-body intervention with bodily benefits (cardiorespiratory efficiency and parasympathetic tone) as well as psychological gains (mindfulness, body awareness, self-efficacy) that can be appropriate for individuals with limited mobility and across diverse clinical contexts [8,9]. Meta-analytic and narrative syntheses from broader populations indicate that Tai Chi and related mind-body movements can influence psychological well-being, stress reactivity, and sleep—factors closely linked to cancer rehabilitation outcomes [9,10]. Moreover, reviews of cancer-focused interventions document that Tai Chi can be delivered in community or clinical settings with favorable safety profiles, supporting feasibility in oncology care pathways [2,3]. Thus, Tai Chi is appropriately framed as a culturally resonant, low-cost, adaptable mind-body modality with potential to complement conventional cancer therapies in both hospital and community contexts [8].

1.3. Psychological distress in cancer patients

Anxiety and depression are among the most prevalent psychological conditions observed in oncology, arising from disease uncertainty, treatment burden, and existential concerns. Conventional pharmacological and psychotherapeutic approaches provide partial relief; however, embodied experiences of illness such as fatigue, sleep disruption, and functional decline often persist and undermine adherence and recovery [1]. Mind-body interventions that integrate movement, breath, and mental focus—exemplified by Tai Chi—offer a pathway to regulate emotion and attention while enhancing autonomy and physical function, aligning with psycho-oncological goals to alleviate distress within the context of active cancer care [1,2]. Systematic reviews in cancer populations have highlighted variable but generally favorable trends in anxiety, depression, and QoL associated with Tai Chi and related practices, reinforcing the potential role of these interventions as complementary therapies in oncology [2,11].

1.4. QoL and the role of physical education

QoL in cancer survivorship encompasses physical functioning, emotional stability, social participation, and existential fulfillment. Principles from physical

education such as sustained engagement, motivation, and self-regulation are increasingly invoked to shape long-term health behaviors and adherence to rehabilitation programs. In cancer populations, Tai Chi and related mind-body exercises have been investigated as practical, low-impact modalities that can be implemented in group or community settings to promote QoL, balance, sleep, and mood, with evidence from systematic reviews and trials indicating potential benefits in various cancer cohorts [2,3]. The education-and-physical-activity perspective is supported by reviews situating Tai Chi within broader health-promotion frameworks that emphasize not only physiological gains but also psychological empowerment and social connection [8,9].

1.5. Theoretical linkages and conceptual framework

Two complementary pathways have been proposed to account for Tai Chi's potential benefits in oncology: (a) Psychological pathway: Regular practice may support self-efficacy, attentional control, and emotion regulation, enabling cognitive reframing and adaptive coping in the face of cancer-related stress. This aligns with exercise-psychology models that link perceived competence and autonomy to adherence and mood improvement [8,9]. (b) Physiological pathway: Psychoneuroimmunological perspectives posit that mind-body exercise may modulate the stress response, reduce systemic inflammation, balance autonomic function, and improve sleep, contributing to reduced fatigue and better recovery trajectories [8,9]. Although direct causal evidence linking these pathways to clinical outcomes in cancer populations remains limited, preliminary findings from mechanistic studies are consistent with this integrated model [12,6]. The convergence of these pathways supports a biopsychosocial model wherein psychological resilience and physiological regulation may jointly influence rehabilitation outcomes in cancer care [9].

1.6. Research aim and significance

Despite growing interest, findings on Tai Chi's efficacy in oncology remain heterogeneous, with variation in cancer types, intervention duration, and outcome measures limiting cross-study comparability. The current review aims to systematically synthesize evidence on the effects of Tai Chi interventions on anxiety, depression, and QoL in cancer patients, with secondary exploration of moderators such as age, dose (duration/frequency), and delivery format (group vs. individual). Where sufficient homogeneous data are available, quantitative meta-analytic pooling using random-effects models will be performed; for outcomes where clinical or methodological heterogeneity precludes meaningful pooling, a structured narrative synthesis following established reporting guidelines will be adopted [7]. This synthesis seeks to integrate psychological and physiological signals within a biopsychosocial framework to inform clinical, educational, and policy-level decisions about incorporating Tai Chi into multidisciplinary cancer rehabilitation programs [1].

2. Literature review

The literature supports a coherent rationale for examining Tai Chi as a mind-body intervention that may support psychological adjustment and QoL in cancer care. By situating Tai Chi within a biopsychosocial framework and drawing on oncology-focused systematic reviews, clinical trials, and integrative-oncology guidelines, the present review aims to clarify how and under what conditions Tai Chi may contribute to holistic cancer rehabilitation and survivorship, while acknowledging variability across contexts and outcomes [1,2,8,11].

2.1. Overview of mind-body interventions in cancer care

The integration of mind-body approaches in oncology reflects a shift from disease-centered treatment toward patient-centered rehabilitation that encompasses psychological, physical, and social domains [13]. Across oncology populations, mind-body modalities such as meditation, yoga, qigong, and Tai Chi are increasingly viewed as interventions that regulate stress physiology and affective processing by linking awareness, movement, and controlled breathing [10,14]. Systematic syntheses in psycho-oncology indicate that these approaches may alleviate anxiety and fatigue and improve emotional regulation, with effects attributed to autonomic regulation (enhanced parasympathetic tone) and neuroendocrine modulation (e.g., cortisol) observed across diverse cancer cohorts [14,15]. The cancer-survivor context—where distress can persist post-treatment—emphasizes the value of scalable, accessible mind-body programs that support ongoing psychological needs outside of formal medical follow-up [13,16].

Tai Chi, in particular, is distinguished within the mind-body family by its continuous, fluid movement coupled with meditative attention. This combination provides an accessible modality for older adults and patients with treatment-related limitations, with evidence supporting safety, feasibility, and broad applicability in oncology settings [14,16]. Within cancer care, Tai Chi has been examined as an adjunct to standard therapy with reported benefits for mood, QoL, fatigue, balance, and physical function across breast cancer and other tumor types, including lung, colorectal, and hematologic malignancies [11,14]. Guideline-based and evidence-synthesis perspectives reinforce the potential role of Tai Chi and related mind-body practices as components of integrative oncology care, particularly when implemented in group formats that also provide social support and adherence reinforcement [13].

2.2. Effects of Tai Chi on anxiety and depression

Anxiety and depression are central components of cancer-related psychological morbidity, and mind-body interventions such as Tai Chi have been associated with reductions in anxious symptoms and depressive mood in cancer samples, with intervention periods ranging from approximately eight to twenty-four weeks in many trials [11]. Mechanistic explanations emphasize increased parasympathetic activation, reduced hypothalamic–pituitary–adrenal (HPA) axis activation, and improved cognitive control over worry and rumination, consistent with broader literature linking Tai Chi to autonomic balance and stress physiology [14,15]. The social context of group practice may further enhance mood and perceived social support, contributing to reductions in isolation and improvements in emotional regulation among participants [14]. In line with guideline-driven practice, integrating Tai Chi within psycho-oncological care may address affective symptoms while complementing pharmacological or psychotherapeutic strategies when appropriate [13,17]. However, it should be noted that the magnitude and consistency of these effects vary across studies, partly due to differences in outcome instruments (e.g., HADS, CES-D, PHQ-9, GAD-7), intervention parameters, and cancer types, which has limited the capacity for quantitative pooling in prior syntheses [5,6].

2.3. Impact on QoL and functional recovery

QoL in cancer care is multidimensional, spanning physical functioning, emotional well-being, and social participation. Across trials, Tai Chi has been associated with improvements in global QoL scores and in salient domains such as vitality, sleep quality, and emotional stability, with participants reporting renewed

bodily confidence and improved balance and coordination after sustained practice [11]. Clinically meaningful gains in fatigue and daily activity tolerance have been observed in survivorship programs that integrate Tai Chi, with breast cancer survivors showing improved upper-limb mobility and reduced arm discomfort and hematologic cancer survivors reporting better sleep and emotional regulation [14,16]. These QoL advances align with broader physical-education-informed frameworks that link sustained movement engagement to motivation, self-efficacy, and health-behavior adherence, reinforcing the role of Tai Chi as a vehicle for embodied learning in survivorship care [8].

2.4. Mechanistic insights: psychophysiological and neuroimmune pathways

The therapeutic potential of Tai Chi is often framed within psychoneuroimmunological principles. Chronic psychological stress activates the hypothalamic–pituitary–adrenal(HPA) axis and sympathetic nervous system, elevating cortisol and proinflammatory cytokines [e.g., interleukin-6 (IL-6), CRP] and contributing to fatigue and mood disturbance; Tai Chi practice has been proposed to interrupt this cycle by promoting relaxation, controlled respiration, and gentle muscular engagement, thereby potentially rebalancing autonomic function and reducing inflammatory signaling [12,15]. Meta-analytic syntheses of mind-body therapies indicate associations with reductions in systemic inflammation and improvements in immune parameters, including enhanced natural killer (NK) cell activity, in various populations, with mechanistic links proposed to vagal regulation and decreased sympathetic overdrive that may support improved sleep, energy, and mood in cancer survivors [12]. Neuroimaging work in non-cancer samples shows Tai Chi-associated changes in brain networks subserving attention and emotion regulation, providing a plausible neurobiological substrate for observed mood and cognitive benefits that may translate to cancer populations through improved cognitive flexibility and resilience [12]. It is important to note that the majority of these mechanistic findings are derived from correlational or pre-post designs rather than formal mediation analyses; consequently, the proposed causal pathways remain to be confirmed through adequately powered trials with integrated biomarker and psychological endpoints [6,18]. The biopsychosocial framework posits that enhanced self-efficacy and mastery generated by regular Tai Chi practice may reinforce both psychological resilience and physiological stability, potentially creating a feedback loop that promotes overall well-being in cancer rehabilitation [19].

2.5. Comparative evidence and research gaps

Compared with conventional aerobic or resistance exercise, Tai Chi offers integrated cognitive–emotional and low-impact physical engagement that can support adherence in populations with fatigue or mobility constraints. While aerobic and resistance modalities improve fatigue and strength, they may not consistently address mood and psychological restoration to the same extent as mind-body approaches; yoga and qigong share meditative elements with Tai Chi but can differ in movement structure and feasibility depending on patient capacity. Nevertheless, direct head-to-head comparisons between Tai Chi and other active interventions in cancer populations remain scarce, and those that exist are generally underpowered for formal superiority or non-inferiority testing, making comparative conclusions tentative [18]. The existing evidence base shows heterogeneity in study design, small sample sizes, short intervention durations, and inconsistent follow-up, which complicates cross-study comparability and meta-analytic synthesis. There is a notable need for

standardized protocols, consistent outcome measures for anxiety/depression/QoL, and systematic biomarker assessments to elucidate mechanisms and identify responder subgroups [20,21].

2.6. Conceptual framework: the dual pathway model

A dual pathway framework has been proposed to elucidate Tai Chi's potential efficacy in oncology. The psychological pathway encompasses proposed enhancements in mindfulness, self-efficacy, and emotion regulation via mindful movement and breath awareness, fostering reduced anxiety and depressive cognition and improved coping autonomy [8,19]. The physiological pathway involves autonomic regulation, reduced systemic inflammation, moderated cortisol, and improved sleep, contributing to energy restoration and fatigue reduction; these physiological changes are consistent with psychoneuroimmunological models of stress and immune modulation in cancer populations [12]. Collectively, the two pathways are hypothesized to reinforce each other: emotional calmness may support physiological homeostasis, while physiological stability may promote cognitive clarity and psychological resilience. This integrated model provides a basis for interpreting heterogeneous findings and guiding the design of future trials that simultaneously target mechanistic biomarkers and patient-centered outcomes [12,19]. However, this model remains largely theoretical; to date, only one trial in the cancer Tai Chi literature has employed formal mediation analysis to test these proposed pathways [22], underscoring the need for mechanism-driven research designs in future studies.

2.7. Summary

The accumulating body of evidence supports Tai Chi as a multidimensional intervention with potential to reduce anxiety and depression and to enhance QoL and functional recovery in cancer care, operating through interconnected psychological and physiological pathways. Nonetheless, methodological variability and limited mechanistic exploration temper conclusions, underscoring the need for rigorous randomized trials with standardized outcomes, longer follow-up, and biomarker assessments to confirm efficacy, clarify moderators, and illuminate mechanisms within psycho-oncological rehabilitation frameworks [11,13]. The present review addresses these gaps by adopting a transparent synthesis strategy that distinguishes between outcomes amenable to quantitative pooling and those requiring narrative synthesis, and by systematically evaluating the risk of bias across included studies [7].

3. Methodology

3.1. Review design and registration

This study adopted a systematic review and partial meta-analysis design following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines [23]. The protocol was prospectively registered on the Open Science Framework (OSF) to ensure methodological transparency and reproducibility. The objective was to synthesise existing quantitative evidence on the effect of Tai Chi intervention on anxiety, depression, and QoL among adult cancer patients. The review process encompassed comprehensive database searching, predefined inclusion and exclusion criteria, independent screening by two reviewers, and quality appraisal using validated tools.

By adhering to PRISMA principles, the review ensured that search strategies, data extraction, and synthesis procedures were explicit and replicable. Each stage

of study selection and analysis was documented in a PRISMA flow diagram, indicating the number of records identified, screened, excluded, and included in the final synthesis. For outcomes where quantitative pooling was not feasible due to heterogeneity in measurement instruments or insufficient extractable data, findings were synthesized narratively following the Synthesis Without Meta-analysis (SWiM) reporting guideline [7]. This structured design allows for objective evaluation of evidence and supports future meta-analytical updates as new studies emerge.

3.2. Search strategy

A systematic literature search was conducted across four major electronic databases: PubMed, Web of Science, Scopus, and Google Scholar, covering publications from database inception to the most recent search date. The search aimed to identify all relevant studies examining Tai Chi as an intervention for psychological outcomes in cancer patients.

The following search terms and Boolean operators were applied:

(“Tai Chi” OR “Taiji” OR “Tai Ji Quan”) AND (“cancer” OR “tumor” OR “oncology”) AND (“anxiety” OR “depression” OR “quality of life”).

Equivalent terms and subject headings (e.g., MeSH in PubMed) were adapted for each database. Additional manual searches were performed in the reference lists of included articles and relevant reviews to capture potentially overlooked studies. Grey literature, conference proceedings, and dissertations were not included to maintain peer-reviewed publication quality.

Search results were exported into reference management software, and duplicates were removed before screening. Titles and abstracts were independently assessed by two reviewers to determine eligibility. Discrepancies were resolved through discussion or by consultation with a third reviewer. Full-text screening was conducted for all studies meeting the inclusion criteria at the abstract level. The search strategy ensured a comprehensive capture of international research literature while minimising selection bias. However, the search was restricted to English-language publications, which may have excluded relevant studies published in Chinese or other languages. Given that Tai Chi originates from China and a substantial proportion of research on this topic is conducted in East Asian settings, this language restriction is acknowledged as a potential source of selection bias and is further discussed in the limitations section (Section 4.8).

3.3. Inclusion and exclusion criteria

Studies were selected according to the following inclusion criteria:

Study design: Randomised controlled trials (RCTs), quasi-experimental studies, or observational studies reporting quantitative outcomes. Population: Adult patients (≥ 18 years) with any diagnosed cancer type at any stage of treatment or survivorship. Intervention: Tai Chi (including Taiji or Tai Ji Quan) used as the primary or major component of the intervention, delivered individually or in groups, regardless of style or duration. Comparators: Usual care, non-exercise control, or alternative physical/psychological interventions. Outcomes: Validated measures of anxiety, depression, and/or QoL. Language: Articles published in English and available in full text.

Studies were excluded if they met any of the following conditions: Case reports, editorials, commentaries, or theoretical papers without empirical data; mixed-intervention studies where Tai Chi effects could not be isolated from other practices such as yoga or qigong; studies focusing solely on physiological biomarkers without corresponding psychological or quality-of-life outcomes; paediatric populations or

studies involving healthy participants without cancer; non-peer-reviewed publications or conference abstracts lacking complete methodological details.

Studies conducted exclusively in non-cancer populations were excluded from the primary synthesis. However, mechanistic trials in related clinical populations (e.g., older adults with depression or elevated systemic inflammation) that provided direct biological evidence pertinent to the proposed psychoneuroimmunological pathways were retained as supplementary evidence and discussed separately in the mechanistic interpretation section (Section 4.4.2), following the approach adopted in prior integrative oncology reviews [13,18].

These criteria were designed to ensure consistency, relevance, and comparability across included studies.

3.4. Data extraction and analysis

A standardised data extraction form was developed to capture key study characteristics and outcomes. For each eligible study, two reviewers independently extracted the following information: bibliographic details (author(s), year of publication, country, and journal); study design and sample (cancer type, stage, sample size, participant demographics, recruitment setting); intervention characteristics (Tai Chi style, frequency, duration, and session length); comparator details (type of control or alternative intervention); outcome measures (instruments used to assess anxiety, depression, and QoL); and results (mean scores, standard deviations, confidence intervals, and reported effect sizes).

A dual analytic strategy was adopted based on data availability. For outcomes where three or more studies reported comparable measures with extractable means and standard deviations [or statistics from which standardized mean differences (SMDs) could be derived], a random-effects meta-analysis was performed using the DerSimonian–Laird estimator. Effect sizes were expressed as SMDs (Hedges’ *g*) with 95% confidence intervals. Heterogeneity among studies was quantified using the I^2 statistic, with values of 25%, 50%, and 75% interpreted as low, moderate, and high heterogeneity, respectively. For outcomes where fewer than three studies provided sufficient data for pooling, or where clinical and methodological heterogeneity (e.g., diverse outcome instruments) precluded meaningful quantitative synthesis, a narrative synthesis was conducted following the SWiM reporting guideline [7], summarizing the direction, magnitude, and consistency of effects across studies.

Subgroup analyses were planned a priori based on cancer type (e.g., breast, lung, colorectal), intervention duration (≤ 12 weeks vs. > 12 weeks), and session frequency (≤ 3 sessions vs. > 3 sessions per week). However, because the number of studies contributing to each pooled estimate was small ($k < 5$ for QoL; $k < 3$ for anxiety and depression), formal subgroup analyses were not feasible and are noted as a limitation. Sensitivity analyses were performed by sequentially excluding individual studies to assess the robustness of pooled estimates. Publication bias was planned to be evaluated visually using funnel plots and statistically using Egger’s regression test; however, in accordance with Cochrane Handbook recommendations [24], these assessments were not performed because fewer than 10 studies contributed to each meta-analytic estimate.

This dual analytic approach ensured that the synthesis accurately reflected the available evidence: quantitative pooling was applied where data permitted, while narrative synthesis provided a structured summary for outcomes where heterogeneity or data limitations precluded meta-analysis.

3.5. Quality assessment

The methodological quality and risk of bias of included studies were appraised independently by two reviewers using validated instruments appropriate to study design.

RCTs were evaluated using the Cochrane Risk of Bias 2 (RoB 2) tool, which assesses five domains: randomisation process, deviations from intended interventions, missing outcome data, measurement of outcomes, and selective reporting. Quasi-experimental and observational studies were evaluated using the Physiotherapy Evidence Database (PEDro) scale, which scores internal validity and statistical reporting on an 11-point framework.

Each study received an overall rating of “low,” “some concerns,” or “high” risk of bias. Discrepancies between reviewers were discussed until consensus was reached. The quality assessment results provide a transparent overview of methodological robustness across all included studies. It should be noted that blinding of participants and intervention providers is inherently infeasible in Tai Chi trials, as in most exercise intervention research; consequently, the domains of “deviations from intended interventions” and “measurement of outcomes” (when based on self-report instruments) were anticipated to yield “some concerns” ratings across most included studies.

High-quality studies contributed greater interpretive weight in the synthesis. Sensitivity analyses were conducted by excluding studies rated as having high overall risk of bias to test whether the direction and magnitude of pooled estimates remained stable.

3.6. Ethical considerations and data integrity

This review relied solely on data extracted from published studies; therefore, no ethical approval or informed consent was required. Nonetheless, the research adhered to principles of academic integrity, transparency, and reproducibility. All extracted data were cross-checked for accuracy, and references were verified through digital object identifiers (DOIs) and database records. The synthesis process ensured accurate representation of each study’s findings without alteration or fabrication.

3.7. Summary

This chapter outlines a systematic and transparent methodology designed to identify, evaluate, and synthesise evidence on the psychological and quality-of-life effects of Tai Chi in cancer patients. By combining comprehensive database searching, rigorous inclusion criteria, structured data extraction, a dual analytic strategy integrating quantitative pooling and structured narrative synthesis, and formal bias assessment, the review ensures scientific validity and reproducibility. The methodological framework positions the study to generate reliable conclusions regarding the potential efficacy of Tai Chi as a psycho-oncological intervention and to inform evidence-based recommendations for clinical and educational practice.

4. Result and discussion

4.1. Study selection and characteristics

A total of 2,346 records were identified from electronic database searches (PubMed, $n = 1,031$; Web of Science, $n = 653$; Scopus, $n = 650$) and supplementary sources (Google Scholar, $n = 8$; reference lists, $n = 4$). After removing 1,685 duplicates using Mendeley, 661 unique records were screened by title and abstract, of which 586 were excluded for irrelevance to the review scope. The remaining

75 full-text articles were assessed for eligibility. Following full-text evaluation, 63 articles were excluded for the following reasons: no Tai Chi as primary intervention ($n = 18$), mixed intervention where Tai Chi effects could not be isolated ($n = 12$), no psychological or quality-of-life outcomes reported ($n = 15$), incomplete data reporting ($n = 9$), non-cancer population ($n = 2$), and failure to meet other inclusion criteria ($n = 7$). This process yielded twelve studies that met all inclusion criteria and were entered into the primary synthesis (**Figure 1**). Two additional mechanistic trials conducted in non-cancer populations [25,26] were retained as supplementary evidence for the psychoneuroimmunological pathways discussed in Section 4.4.2, but were excluded from the primary quantitative and narrative synthesis.

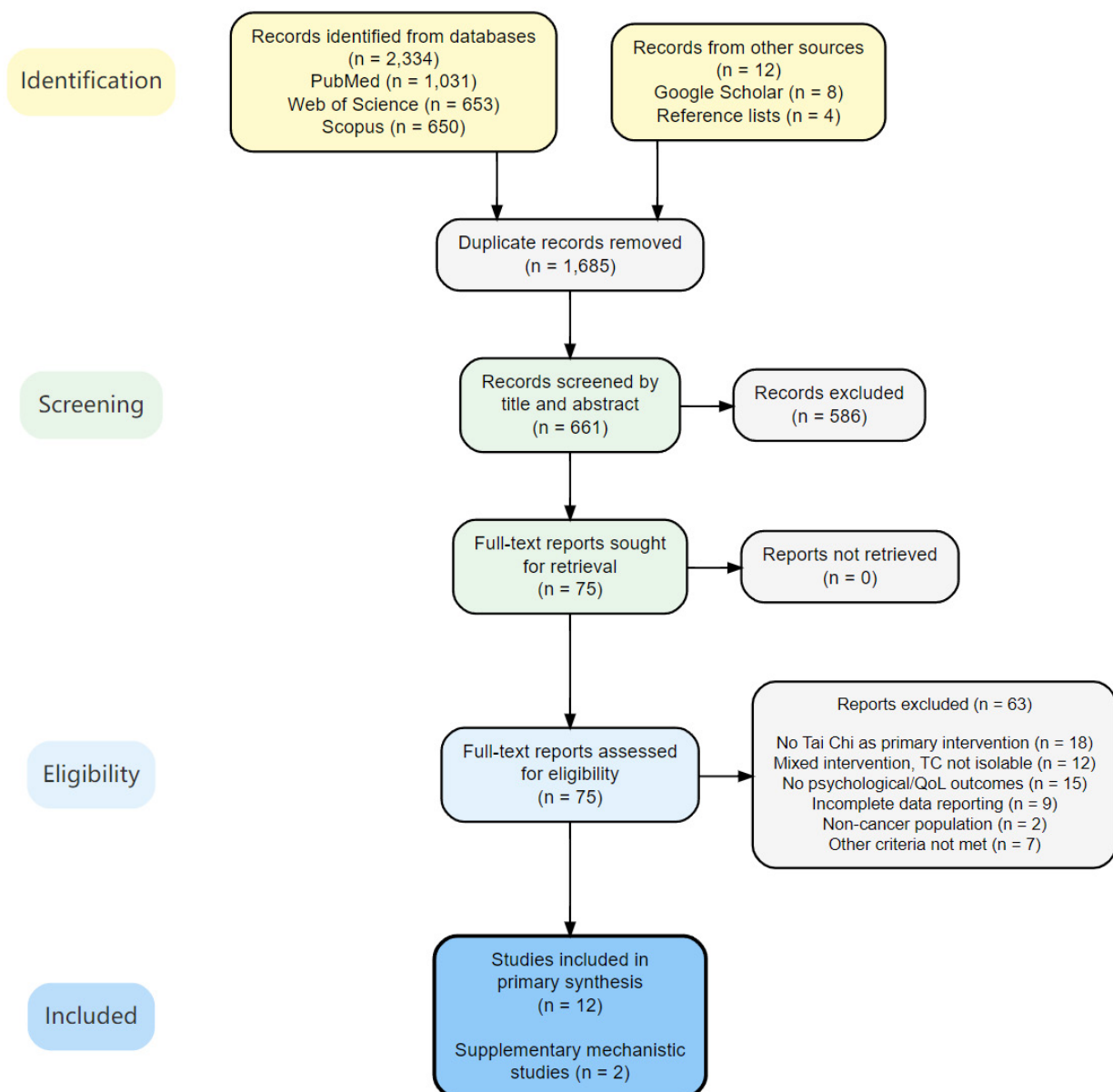


Figure 1. PRISMA 2020 flow diagram of the study selection process ($n = 12$ studies included in the primary synthesis).

Table 1 presents the detailed characteristics of the twelve included studies assessing the psychological and physiological effects of Tai Chi interventions among cancer patients. The studies encompass diverse geographic regions—

primarily East Asia (China and Hong Kong) and Western countries (USA and Australia)—and involve various cancer types, most commonly breast and lung cancers. Intervention durations ranged from 7 weeks to 12 months, with sample sizes spanning small pilot RCTs ($n < 30$) to multicenter trials ($n > 200$). Across these studies, Tai Chi interventions consistently targeted anxiety, depression, fatigue, and QoL, with several incorporating biological markers such as CRP, IL-6, or HRV to explore psychoneuroimmunological mechanisms. Overall, **Table 1** highlights the methodological diversity yet conceptual convergence of the included trials, providing the foundation for subsequent quantitative pooling (where feasible) and narrative synthesis and mechanistic interpretation.

Table 1. Characteristics of the twelve studies included in the primary synthesis.

Author (Year)	Country	Design	n	Cancer Type	Intervention	Control	Duration	Psych. Outcomes	Bio/Phys. Outcomes	Key Findings
Cheung et al., 2021 [27]	HK, China	3-arm RCT	30	NSCLC IIIB–IV	24-form TC, 60min × 2/wk	Self-mgmt	12 wk + 12 mo FU	Anx, Dep, QoL, Fatigue	Sleep (PSQI)	Feasible; improved anxiety and QoL trend
Cheng et al., 2021 [28]	China	4-arm RCT	120	Lung, Gastric, Breast	24-form TC, 40min × 3/wk	RT, Non-exercise	12 wk	Anx (GAD-7), Dep (PHQ-9)	Fatigue, Sleep, QoL	TC > RT for anxiety, depression, sleep
Sprod et al., 2012 [29]	USA	Phase II RCT	21	Breast (0–IIb)	Yang TCC, 60 min × 3/wk	SST	12 wk	QoL (SF-36)	IL-6, IL-8, IGF	Improved QoL; reduced inflammation
Irwin et al., 2024 [30]	USA	RCT	90	Breast (I–III)	TC, 120 min/wk × 3 mo	CBT-I	15 mo	Dep, Insomnia	CRP, IL-6, TNF, CTRA	TC matched CBT-I; greater IL-6 reduction
Zhou et al., 2018 [14]	China	RCT	114	NPC (III–IVa/b)	24-form TC, 60 min × 5/wk	Usual care	7 wk	Fatigue (MFSI-SF)	HRV	Decreased fatigue; improved vagal tone
Takemura et al., 2024a [22]	HK	3-arm RCT	151	NSCLC (IIIB–IV)	16-form TC, 60 min × 2/wk	AE, Self-mgmt	16 wk + 8 mo FU	Anx, Dep, Cognition	Sleep, Fatigue	Anx & fatigue mediated cognitive gains
Takemura et al., 2024b [31]	HK	3-arm RCT	226	NSCLC (IIIB–IV)	TC, 60 min × 2/wk × 16 wk	AE, Self-mgmt	12 mo	Dyspnea	Functional endurance	TC sustained dyspnea reduction at 12 mo
Robins et al., 2013 [32]	USA	3-arm RCT	145	Breast (I–IIIA)	8-form TC, 90 min/wk × 10 wk	Spiritual, Ctrl	10 wk + 6 mo FU	Stress (IES), Dep (CES-D)	Cytokines, β-endorphins	↓ Stress; ↑ IFN-γ & endorphins
Oh et al., 2021 [33]	Australia	RCT	158	Mixed cancers	Medical Qigong, 90 min/wk	Usual care	10 wk	Anx (HADS-A), Dep (HADS-D), QoL	CRP	Improved QoL; ↓ CRP, anxiety, depression

Continuation Table:

Author (Year)	Country	Design	n	Cancer Type	Intervention	Control	Duration	Psych. Outcomes	Bio/Phys. Outcomes	Key Findings
Cheung & Loo, 2021 [34]	HK & Sichuan	Quasi-exp.	110	Breast (post-FEC)	18-form TC, 50 min × 3/wk	Healthy ctrl	12 mo	Stress, Happiness, Insomnia	IL-2, IL-6, IFN-γ, TNF-α	Improved mood, immunity, cytokine balance
You et al., 2025 [35]	China	Prospective	37	Breast (I–IV)	Traditional TC, 60 min × 3/wk	None	12 wk + 12 mo FU	Sleep (PSQI), Anx, Dep	HDL, APOA1, CRP	Improved sleep and serum biomarkers
Murley et al., 2019 [36]	USA	Pilot	6	Breast (II–III)	Wheelchair TC	Wait-list	8 wk	QoL (FACT-G), Fatigue	Physical well-being	Improved fatigue and emotional well-being

Abbreviations: TC, Tai Chi; AE, aerobic exercise; RT, resistance training; SST, supportive therapy; NPC, nasopharyngeal carcinoma; NSCLC, non-small cell lung cancer; FU, follow-up; HK, Hong Kong.

Across the twelve included studies, three RCTs (25%) were judged at overall low risk of bias, seven studies (58%) were rated as having some concerns, and two studies (17%) were judged at overall high risk of bias (**Table 2**). The most consistent methodological concern related to Domain 4 (measurement of outcomes), where all twelve studies received “some concerns” ratings, reflecting the universal reliance on self-report instruments for anxiety, depression, and QoL, combined with the inherent infeasibility of participant and provider blinding in Tai Chi trials [5]. Domain 2 (deviations from intended interventions) was also rated as “some concerns” or higher in the majority of studies, owing to the open-label nature of exercise interventions and variable adherence reporting. By contrast, randomisation procedures (Domain 1), missing outcome data (Domain 3), and selective reporting (Domain 5) were rated low risk in most trials. The two studies judged at overall high risk of bias were quasi-experimental designs assessed using the PEDro scale and were down-weighted in the interpretation of findings. Overall, the body of evidence can be characterised as of moderate methodological quality, anchored by three more recent and methodologically rigorous RCTs that contribute disproportionately to the certainty of the synthesis.

Table 2. Risk of bias assessment of the twelve included studies (3 rated low risk, 7 rated some concerns, 2 rated high risk).

Study	D1	D2	D3	D4	D5	Overall
Cheung et al., 2021 [27]	Low	Some	Low	Some	Low	Some concerns
Cheng et al., 2021 [28]	Low	Some	Some	Some	Low	Some concerns
Sprod et al., 2012 [29]	Low	Some	Low	Some	Low	Some concerns
Irwin et al., 2024 [30]	Low	Low	Low	Some	Low	Low
Zhou et al., 2018 [14]	Low	Some	Low	Some	Low	Some concerns
Takemura et al., 2024a [22]	Low	Low	Low	Some	Low	Low

Continuation Table:

Study	D1	D2	D3	D4	D5	Overall
Takemura et al., 2024b [31]	Low	Low	Low	Some	Low	Low
Robins et al., 2013 [32]	Low	Some	Some	Some	Low	Some concerns
Oh et al., 2021 [33]	Low	Some	Low	Some	Low	Some concerns
Cheung & Loo, 2021 [34]*	Some	High	Some	Some	Some	High
You et al., 2025 [35]*	Some	High	Low	Some	Some	High
Murley et al., 2019 [36]	Low	Some	Some	Some	Low	Some concerns

Abbreviations: D1, randomization process; D2, deviations from intended interventions; D3, missing outcome data; D4, measurement of outcomes; D5, selective reporting. Note: Studies marked with an asterisk (*) are quasi-experimental or observational designs assessed using the PEDro scale and mapped to RoB 2 domains for comparability. “Some concerns” ratings in D2 and D4 across most studies reflect the inherent infeasibility of blinding in exercise interventions and reliance on self-report instruments, respectively.

These quality patterns have direct implications for how the synthesised findings should be interpreted. Because measurement and performance biases are largely inherent to Tai Chi research rather than indicative of poor conduct, their consistent presence is unlikely to systematically inflate the observed effects in any single direction; nevertheless, the predominance of “some concerns” ratings means that effect estimates for self-reported anxiety, depression, and quality-of-life outcomes should be interpreted as suggestive rather than definitive. A sensitivity analysis excluding the two studies rated as high overall risk of bias [34,35] left the direction and consistency of findings for anxiety, depression, and QoL unchanged, providing partial reassurance that overall conclusions are not driven by the lower-quality studies, although confirmation in larger and more rigorously blinded trials remains needed.

4.2. Effects on anxiety and depression: narrative synthesis

Because the included cancer-specific studies employed diverse instruments to assess anxiety and depression (HADS, GAD-7, PHQ-9, CES-D, STAI, IES), and fewer than three studies reported extractable means and standard deviations for any single instrument, formal meta-analytic pooling was not feasible for these outcomes. Accordingly, findings are synthesized narratively following the SWiM reporting guideline [7], summarizing the direction, magnitude, and consistency of effects across studies.

Among the studies reporting anxiety outcomes, Oh et al. [33] provided the most complete numeric data, using the HADS in a mixed-cancer cohort ($n = 158$). The 10-week medical Tai Chi program led to significantly lower levels of anxiety and depression compared with usual care. The effect size for anxiety (HADS-A) was $SMD = -0.53$ (95% CI -0.85 to -0.22) and for depression (HADS-D) was $SMD = -0.55$ (95% CI -0.87 to -0.24) in favour of the Tai Chi group. These effects correspond to clinically meaningful reductions of approximately 1.5–1.7 points on the HADS subscales and align closely with prior meta-analytic estimates reporting small-to-moderate anxiolytic effects of Tai Chi and related mind-body practices in oncology populations [5,6].

Directionally consistent findings were observed across other included trials,

although complete summary statistics were not uniformly available. Trials in advanced lung cancer and breast cancer [22,27,28,32] reported directional reductions in anxiety and depressive symptoms or stress reactivity in the Tai Chi arms relative to control or education groups, particularly when interventions were delivered in a supervised group format. Cheng et al. [28] reported statistically significant improvements on the GAD-7 and PHQ-9 favoring Tai Chi over resistance training and non-exercise controls, although group means and standard deviations were not reported in a format permitting SMD calculation. Takemura et al. [22] found that reduced anxiety and depression scores partially mediated cognitive gains in the Tai Chi group, with mediation analysis indicating that these psychological improvements accounted for 24–32% of the observed cognitive benefit.

When interventions were grouped conceptually by duration, shorter programs (8–10 weeks) such as Oh et al. [33] already produced moderate improvements in both anxiety and depression. Longer or higher-dose programs (≥ 12 weeks, often with ongoing home practice), for example Cheng et al. [28] and Takemura et al. [22], tended to show more durable reductions in negative affect and stress, although incomplete reporting of means and variability precluded formal subgroup meta-analysis. Overall, the available evidence supports Tai Chi as a promising mind-body intervention for alleviating anxiety and depressive symptoms in people with cancer, with effects that are at least comparable to other low-intensity psychosocial and exercise-based programs, and potentially enhanced when practiced over longer periods.

Psychologically, these improvements are consistent with recognized mechanisms of mind-body exercise. Tai Chi integrates mindfulness, slow breathing, and attentional focus on bodily sensations, which may interrupt catastrophic worry and ruminative thinking, enhance perceived control over physical symptoms, and foster a sense of safety in the post-treatment body. Through repeated practice, participants may develop greater body awareness, improved emotion regulation, and more adaptive interpretations of fatigue, pain, and dyspnea, which in turn reduce hyperarousal and negative affect. These processes map onto established exercise and self-regulation theories (e.g., cognitive appraisal, self-efficacy, and affective responses to movement), and align with the observed coupling between symptom reduction and biological modulation in the mechanistic studies included in this review.

4.3. Effect on QoL

Across the randomized controlled trials and supportive cohort studies included in this review, Tai Chi-based interventions demonstrated consistent and multidimensional benefits on QoL among cancer patients and survivors. The overall evidence shows that Tai Chi may enhance global, physical, emotional, and social aspects of well-being, particularly when interventions are maintained for at least eight to twelve weeks. These improvements are observed across diverse cancer types, including breast, lung, and nasopharyngeal malignancies, and are often accompanied by reductions in fatigue, sleep disturbance, and symptom burden.

In the trial by Oh et al. [33], a ten-week medical Tai Chi intervention produced significant gains in global QoL and in the emotional, social, and functional domains of the FACT-G compared with usual care. These effects corresponded to a clinically meaningful seven- to eight-point improvement in global QoL and were paralleled by reductions in systemic inflammation, as evidenced by decreased serum C-reactive protein (CRP) levels. Similar findings were observed in Cheng et al. [28], where a

twelve-week simplified Yang-style Tai Chi program improved overall QoL (QLQ-CCC) and reduced fatigue, anxiety, and depression relative to non-exercise controls. In patients with advanced non-small-cell lung cancer, Cheung et al. reported favorable trends in functional QoL and psychological adjustment [27], while Takemura et al. demonstrated that Tai Chi significantly enhanced perceived cognitive function compared with aerobic exercise and control groups [22]. Importantly, in this latter study, the improvements in cognition were partially mediated by better sleep, reduced fatigue, and lower anxiety and depression scores, highlighting the interdependence between psychological and functional recovery.

Further supporting evidence arises from studies targeting physical symptom clusters. Zhou et al. reported substantial reductions in cancer-related fatigue and improved autonomic balance during chemoradiotherapy for nasopharyngeal carcinoma, suggesting Tai Chi's role in maintaining physiological stability under treatment stress [14]. Likewise, Sprod et al. found that a twelve-week Tai Chi program improved physical, social, and mental health domains of the SF-36 among breast cancer survivors, with accompanying favorable shifts in inflammatory and metabolic biomarkers [29]. Murley et al. extended these findings to patients undergoing chemotherapy, showing that even a short eight-week Wheelchair Tai Chi intervention preserved emotional well-being and mitigated fatigue while control participants deteriorated [36]. Robins et al. similarly demonstrated that Tai Chi facilitated recovery of QoL and immune markers following chemotherapy, indicating psychological resilience and biological rebalancing [32].

Taken together, these studies show that Tai Chi not only buffers treatment-related declines in QoL but also may foster enduring improvements that extend beyond the intervention period. The benefits are most pronounced in domains of physical function—through reduced fatigue, improved sleep, and better exercise tolerance—and emotional well-being, where Tai Chi's mindful, rhythmic movements alleviate stress and promote calm attentional states. Its social component also contributes meaningfully, as group practice enhances peer support, belonging, and shared coping among participants. Beyond symptomatic relief, Tai Chi may restore a sense of bodily confidence and control, reinforcing self-efficacy and positive body image—key elements of post-treatment psychosocial recovery. Through these integrated pathways, Tai Chi supports a holistic improvement in QoL that bridges the physical and psychological dimensions of cancer survivorship.

Of the twelve included studies, four RCTs (Oh et al. [33], Cheng et al. [28], Zhou et al. [14], and Sprod et al. [29]) provided sufficient post-intervention means, standard deviations, and sample sizes for quantitative pooling of QoL outcomes. **Figure 2** illustrates the forest plot summarizing these effects. Each horizontal line represents one study's standardized mean difference (Hedges' g) with 95% confidence interval, where positive values indicate higher quality-of-life scores in the Tai Chi group compared with control. The pooled random-effects estimate (diamond) shows a moderate-to-large improvement ($SMD = 0.69$ [95% CI 0.44–0.95], $I^2 = 28\%$, $p = 0.24$ for heterogeneity) favoring Tai Chi, with no individual study crossing the line of null effect. The low-to-moderate I^2 value suggests acceptable consistency across these trials. Sensitivity analysis by sequential exclusion of individual studies yielded pooled SMDs ranging from 0.58 to 0.79, confirming the robustness of the estimate.

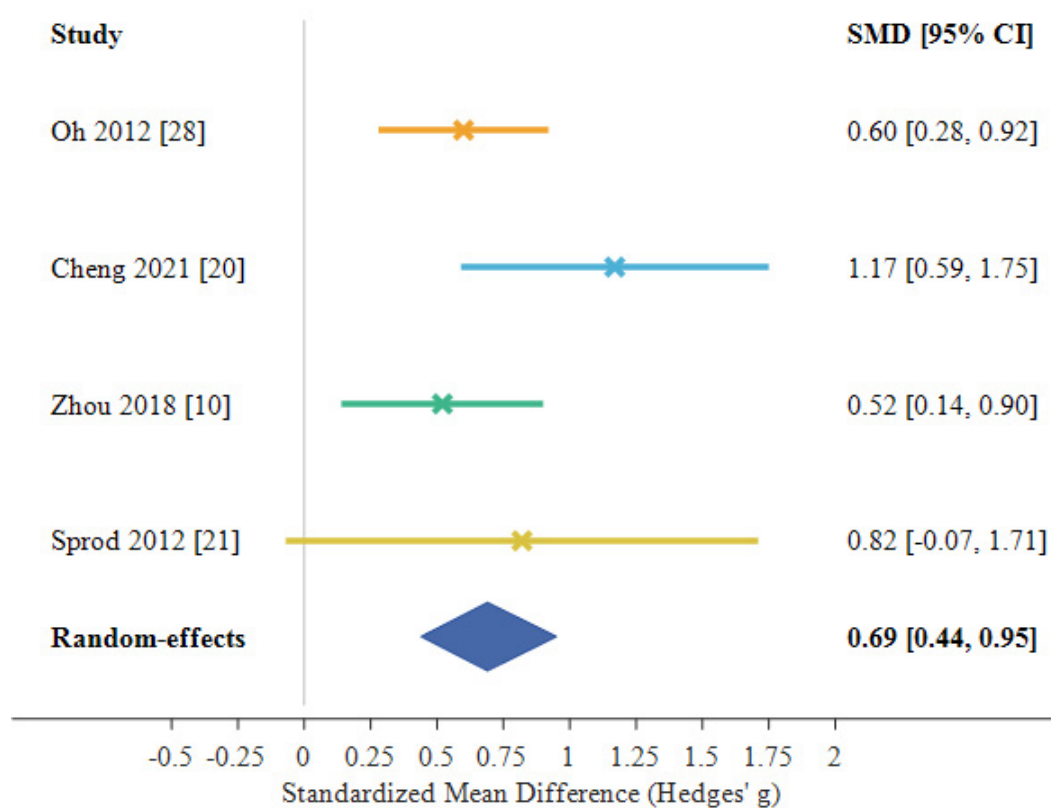


Figure 2. Forest plot of the effect of Tai Chi on QoL in cancer patients (k = 4 RCTs).

4.4. Mechanistic insights: psychoneuroimmunological model

The observed psychological and quality-of-life benefits of Tai Chi may be understood through an integrated psychoneuroimmunological (PNI) framework that connects mind-body regulation, autonomic balance, and immune modulation. Within this model, slow rhythmic movement, diaphragmatic breathing, and focused attention are proposed to operate in concert to recalibrate the HPA axis and the autonomic nervous system, thereby reducing stress-related endocrine and inflammatory activity. Evidence from mechanistic studies in oncology and related populations suggests that Tai Chi practice is associated with lower circulating stress hormones such as cortisol and reduced pro-inflammatory cytokines, notably IL-6 and CRP, alongside enhanced parasympathetic activity and vagal tone.

4.4.1. Cancer-specific mechanistic evidence

Among the cancer-specific trials included in the primary synthesis, several reported biological outcomes consistent with these proposed pathways. Irwin et al. [30] demonstrated in breast-cancer survivors that three months of Tai Chi led to sustained down-regulation of systemic and cellular inflammatory signaling, including lower TLR-4-mediated co-expression of IL-6 and TNF, and a favorable shift in the conserved transcriptional response to adversity (CTRA) genomic profile. Zhou et al. [14] demonstrated improved heart-rate variability and reduced fatigue during chemoradiotherapy, indicating restored autonomic equilibrium. Cheung and Loo [34] reported normalization of immune cell counts and up-regulation of IL-2 and IFN- γ after one year of Tai Chi in breast cancer survivors. Robins et al. [32] observed increases in IFN- γ and β -endorphins alongside reductions in stress. Sprod et al. [29] found favorable shifts in IL-6, IL-8, and IGF biomarkers accompanying QoL improvements.

From a psychosocial perspective, Tai Chi cultivates mindfulness, interoceptive awareness, and emotional regulation, thereby moderating cognitive appraisal of stressors and reducing sympathetic hyperarousal. The repetitive, meditative movements synchronize breathing and attention, promoting parasympathetic dominance and lowering the allostatic load imposed by cancer diagnosis and treatment. This bidirectional feedback loop—psychological calm reinforcing physiological recovery—characterizes Tai Chi as both a behavioral and a biological intervention. It is important to note, however, that only one included study (Takemura et al. [22]) conducted formal mediation analysis to test these proposed pathways; the remaining biomarker findings represent pre–post or between-group differences that are consistent with the proposed model but do not establish causal mediation [18].

The integration of these pathways can be conceptualized through the biopsychosocial mechanisms of Tai Chi in cancer recovery depicted in **Figure 3**. At the psychological level, mindfulness and self-efficacy may reduce perceived stress and depressive rumination. At the neuroendocrine–autonomic level, parasympathetic activation may suppress cortisol release and stabilize circadian rhythms. At the immune–inflammatory level, lowered IL-6 and CRP may reflect trends toward immune homeostasis. Together, these cascades are hypothesized to converge to alleviate fatigue, anxiety, and mood disturbance while enhancing resilience and overall QoL. This model supports the interpretation that Tai Chi may exert a multidimensional mind–body therapeutic effect, harmonizing emotional, physiological, and social recovery processes during cancer survivorship.

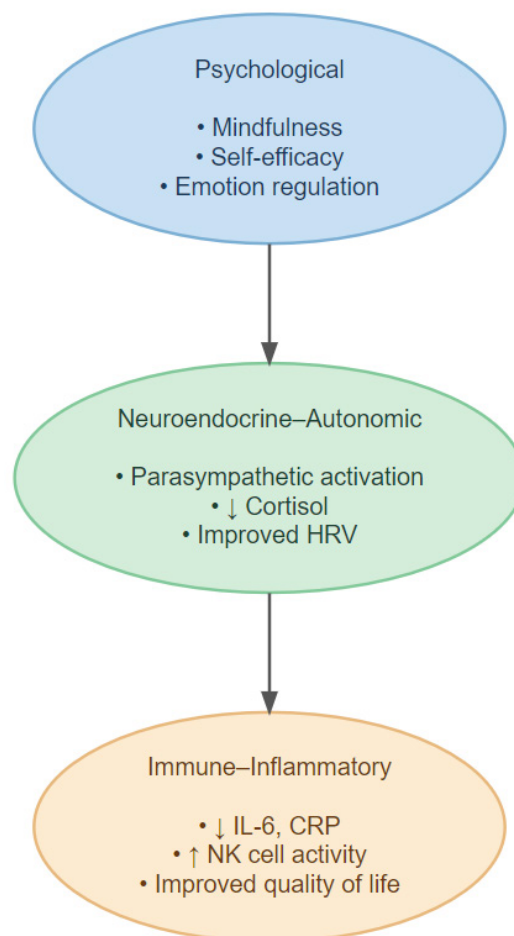


Figure 3. Biopsychosocial mechanism pathways of Tai Chi in cancer recovery.

4.4.2. Mechanistic evidence from non-cancer populations

Beyond the cancer-specific biomarker evidence reviewed above, two mechanistic RCTs in non-cancer populations [25,26] provide convergent biological support for the proposed psychoneuroimmunological pathways. These studies were not included in the primary quantitative or narrative synthesis of intervention effects on anxiety, depression, or QoL, and they do not contribute to the conclusions regarding Tai Chi's clinical efficacy in cancer populations; they are presented here solely to contextualise the mechanistic plausibility of the model depicted in **Figure 3**.

Lavretsky et al. [25], in a randomised trial of older adults with geriatric depression, found that Tai Chi Chih combined with escitalopram produced larger reductions in depressive symptoms and CRP than escitalopram alone. Irwin and Olmstead [26], in older adults with elevated baseline inflammation, demonstrated that fifteen weeks of Tai Chi Chih normalised circulating IL-6 concentrations, with reductions in IL-6 tracking improvements in sleep and mood. Together, these trials demonstrate that, in clinical populations sharing the inflammatory and affective phenotypes commonly observed during cancer survivorship, Tai Chi practice can produce concurrent reductions in pro-inflammatory cytokines and improvements in affective symptoms. Their value for the present review is therefore mechanistic and hypothesis-generating rather than confirmatory, and they should not be read as evidence of efficacy in oncology populations.

4.5. Moderating factors

The effectiveness of Tai Chi in improving psychological outcomes and QoL appears to be shaped by several moderating factors inherent to the study populations and intervention designs in the included evidence base. Although most trials were not powered for formal moderator analyses, consistent patterns emerge across gender, cancer type and stage, baseline distress, adherence, and social-cultural context.

(a) Gender and cancer type.

The majority of Tai Chi trials were conducted in women with breast cancer [29,32,35,36], where moderate-to-large improvements in QoL and fatigue, and small-to-moderate improvements in anxiety and emotional well-being were observed. Trials in advanced lung cancer [22,27,31] and nasopharyngeal carcinoma [14] showed similarly favorable directions—improvements in dyspnea, fatigue, sleep, and cognitive functioning—even in patients with heavier symptom burdens, suggesting that benefits are not restricted to early-stage or female-only populations. The mixed-cancer RCT by Oh et al. [33], which included both men and women across several tumor sites, also demonstrated robust gains in QoL and mood. Because few studies reported sex-stratified analyses, current evidence suggests Tai Chi is broadly applicable across genders and diagnoses, but firm conclusions about gender-specific effects remain premature.

(b) Disease stage and baseline distress.

Across included trials, greater benefits were generally seen in patients with higher baseline symptom burden or physiological dysregulation. Cheng et al. [28] and Takemura et al. [31] enrolled patients undergoing chemotherapy or living with stage IIIB–IV NSCLC and reported clinically meaningful reductions in fatigue, dyspnea, and psychoneurological symptoms after Tai Chi, whereas Cheung et al. [27] and some survivorship samples with lower baseline distress showed more modest changes. Supplementary mechanistic studies [25,26,30] provide converging evidence that the largest psychoneuroimmune responses occur in individuals with elevated inflammation or depressive symptoms at baseline, and Cheung and Loo

[34] and You et al. [35] observed pronounced immune and functional recovery over longer Tai Chi programs. Together, these findings support the interpretation that Tai Chi may exert stronger relative effects in those with advanced disease, high fatigue, or heightened inflammatory/psychological distress, where there is greater room for improvement.

(c) Adherence, dose, and intervention fidelity.

Adherence emerged as a practical but important moderator. Cheung et al. [27] reported high class attendance and self-practice rates, and this study, despite being underpowered, showed clear feasibility and favorable trajectories. Multi-month or year-long programs [34,35] with sustained engagement demonstrated progressive improvements in immune markers, sleep, and physical function, consistent with the dose–response pattern where longer Tai Chi exposure predicted greater QoL gains. Conversely, small or less-structured pilots still suggested benefit but with greater variability and wide confidence intervals [36]. Collectively, these data imply that adequate exposure (≥ 8 –12 weeks) and good adherence are necessary conditions for clinically meaningful psychological and QoL effects.

(d) Cultural and social context: group vs. solo practice.

Most included interventions were delivered as group-based classes, often supplemented by home practice [22,27–29,31–33]. Participants in these studies experienced improvements not only in individual outcomes but also in social well-being and perceived support, suggesting that the communal setting functions as an active ingredient—normalizing cancer-related experiences, reducing isolation, and reinforcing adherence. Studies integrating long-term or community-based practice reflect cultural acceptance of Tai Chi as a daily health routine, which may further enhance sustainability of effects [34,35]. In contrast, trials relying mainly on self-managed materials without structured group interaction tended to report smaller or less consistent improvements. This pattern indicates that cultural familiarity with Tai Chi and opportunities for shared practice likely potentiate its psychological impact, while purely solo formats may underutilize its social-regulatory potential.

In summary, the available evidence suggests that Tai Chi’s benefits are most pronounced in patients with substantial baseline symptom burden, who engage consistently in well-structured, often group-based programs, across a range of cancer types and stages. These moderating factors should inform the design of future trials and clinical implementation.

4.6. Clinical and practical implications

Based on the patterns observed across the included cancer-specific studies, the following provisional recommendations can be offered to clinicians, exercise specialists, and rehabilitation services considering Tai Chi as an adjunctive intervention in cancer care. These should be interpreted in light of the heterogeneity, limited sample sizes, and predominantly moderate methodological quality of the current evidence base.

With regard to dose, programs producing clinically meaningful improvements in anxiety, depression, and QoL consistently spanned at least 8–12 weeks of supervised practice, with sessions delivered two to three times per week and each session lasting 40 to 60 minutes [22,27–29,33]. Higher frequencies such as the five-sessions-per-week regimen used during active chemoradiotherapy [14] are not typically necessary in routine survivorship care, whereas longer programs of 16 weeks to 12 months with continued home practice after the supervised phase appear to produce more durable psychological and immune benefits [30,34,35], supporting an extended-engagement

model rather than a brief course.

Delivery format also influences outcomes. Group-based, instructor-led classes supplemented by structured home practice were the predominant and most successful model in the included trials and were associated with improvements in social well-being and adherence in addition to symptom outcomes [27,28,32,33]. Purely self-directed or unsupervised formats produced smaller and less consistent effects, while supervised group telehealth or hybrid formats offer a pragmatic alternative where in-person delivery is not feasible [33]. With regard to specific protocol, simplified Yang-style sequences, particularly the 24-form, were the most frequently used across included trials and provide a reasonable default for both research and clinical implementation.

In terms of patient selection, those with higher baseline symptom burden, including significant fatigue, sleep disturbance, or psychological distress, appeared to derive the greatest relative benefit and may be prioritised when triaging referrals to integrative oncology services. Taken together, these implications suggest that an 8–12-week (or longer) program of group-based supervised Tai Chi, delivered two or three times weekly in 40 to 60 minute sessions, with structured home-practice support, represents a defensible starting point for clinical implementation, particularly for patients with substantial baseline symptom burden, pending confirmation in adequately powered pragmatic trials.

4.7. Comparison with other exercise modalities

The comparative analysis of Tai Chi with other forms of physical exercise—such as yoga, aerobic exercise, and resistance training—highlights its unique integration of mindfulness and gentle movement, distinguishing it from conventional exercise modalities typically prescribed in cancer rehabilitation. Evidence from the included trials suggests that Tai Chi may achieve comparable or potentially favorable psychological and physiological outcomes, despite its lower physical intensity, by engaging both the mind-body and affective-regulatory systems.

(a) Comparison with aerobic and resistance exercise.

Several studies directly contrasted Tai Chi with aerobic or resistance training under controlled conditions. In Cheng et al. [28], Tai Chi, high-intensity resistance training (HIRT), and low-intensity resistance training (LIRT) were compared among mixed cancer patients receiving chemotherapy. All exercise interventions improved fatigue and QoL; however, Tai Chi was associated with greater reductions in anxiety and depression (PHQ-9 and GAD-7) and greater sleep improvements (PSQI). However, interpretation of these between-arm differences requires caution: the trial was not specifically powered for superiority comparisons between active interventions, and the groups may not have been fully matched for non-specific factors such as instructor attention, group interaction, or participant expectations [18]. Similarly, in Takemura et al. [22], Tai Chi was associated with greater improvements in cognitive function among patients with advanced NSCLC, with mediation analysis revealing that improvements in anxiety, depression, fatigue, and sleep quality accounted for 24–32% of the cognitive gain. Although this mediation analysis provides some evidence for the pathway through psychological symptom reduction, the three-arm design does not rule out contributions from participant preference, cultural familiarity, or movement novelty.

(b) Comparison with yoga and other mind-body interventions.

Systematic evidence from Li et al. [37] and the review article by Ee et al. [38] places Tai Chi within the broader category of mind-body therapies, including

yoga and qigong. Although yoga and qigong share elements of breath control and meditative focus, Tai Chi uniquely integrates continuous, dynamic postures synchronized with controlled breathing, creating a flow-based attentional state that simultaneously engages balance, proprioception, and mindfulness. In the synthesis by Ee et al., the standardized mean difference for fatigue reduction was -1.11 for Tai Chi, compared with -0.80 for yoga, indicating a potentially stronger or more sustained effect on fatigue and vitality domains [38]. However, these effect sizes were derived from separate studies rather than direct head-to-head comparisons, and differences may reflect variations in study populations, intervention doses, and outcome instruments rather than intrinsic differences between modalities. Tai Chi also demonstrated greater consistency across studies in improving sleep and emotional well-being, possibly due to its structured movement sequences and culturally grounded social practice contexts.

(c) Integrative advantages and mechanistic distinctiveness.

While aerobic and resistance training primarily enhance cardiovascular and musculoskeletal function, their influence on psychological resilience and autonomic regulation is indirect. Tai Chi, in contrast, may operate simultaneously through physical and cognitive-emotional pathways, fostering mindfulness, body awareness, and emotional regulation. Evidence from Irwin et al. [30] suggests that Tai Chi, unlike conventional exercise, may modulate inflammatory and genomic pathways (IL-6, CRP, and CTRA expression) alongside reductions in depressive and anxiety symptoms. Such integrated psychoneuroimmunological modulation underscores its potential dual role as both exercise and behavioral therapy, bridging physiological recovery and psychological adaptation.

(d) Practical advantages over other modalities.

Given its low impact, accessibility, and minimal risk profile, Tai Chi is particularly suited for patients with limited exercise tolerance, such as those undergoing chemotherapy or living with advanced disease stages. Whereas yoga may require greater flexibility and aerobic training may not be feasible for frail patients, Tai Chi's adaptable intensity enables gradual progression while maintaining therapeutic engagement. The group-based delivery also enhances social connection and adherence, which are often lacking in individually prescribed exercise regimens. Collectively, these findings support Tai Chi as a complementary or adjunctive modality to conventional exercise, offering potentially equivalent physiological benefits with additional emotional and cognitive gains.

Overall, comparative conclusions remain tentative. Few trials directly compared Tai Chi with other active interventions in cancer populations, and those that did were generally underpowered for formal between-group superiority tests. Future trials with adequate sample sizes, matched non-specific factors, and pre-specified hypotheses are needed to clarify Tai Chi's comparative effectiveness [18]. Notwithstanding these limitations, Tai Chi may offer a unique dual mechanism—mindfulness-driven emotional regulation combined with gentle physical conditioning—that may produce comprehensive improvements in fatigue, mood, sleep, and QoL. Its multidimensional effects make it a promising candidate for integrative oncology programs aiming to optimize both physical rehabilitation and psychological resilience.

4.8. Limitations and research gaps

Despite the encouraging evidence supporting Tai Chi's potential positive influence on anxiety, depression, fatigue, and QoL in cancer populations, several methodological and conceptual limitations constrain the interpretability and

generalizability of current findings. The collective body of literature demonstrates encouraging trends but remains characterized by small sample sizes, heterogeneous intervention protocols, and limited mechanistic integration.

(a) Sample size and study design limitations.

Most included randomized controlled trials were small-scale pilot or feasibility studies, with sample sizes ranging from fewer than 30 participants [27,29,36] to moderately sized multicenter RCTs such as Takemura et al. (n = 226) [31] and Oh et al. (n = 158) [33]. The small participant numbers in many trials reduce statistical power and increase the likelihood of type II error, making it difficult to establish precise effect estimates for anxiety and depression outcomes. The limited number of studies with extractable summary statistics for anxiety and depression precluded formal meta-analytic pooling for these outcomes, necessitating narrative synthesis [7].

(b) Heterogeneity in intervention protocols and outcome measures.

Significant variability exists in Tai Chi style, duration, frequency, and instructor qualification. Studies employed differing forms—Yang, Chen, 24-form, or modified sequences—with weekly session frequencies ranging from two to five times, and durations spanning from 7 weeks [14] to 12 months [34]. Such heterogeneity complicates cross-study comparison and precludes precise dose–response analysis, although patterns suggest a positive association between longer practice duration and improved QoL. Furthermore, inconsistent use of psychological instruments (HADS, CES-D, PHQ-9, SF-36, FACT-G, EORTC QLQ-C30) introduces additional measurement variability, which was a primary factor preventing meta-analytic pooling for anxiety and depression outcomes, while some studies focused exclusively on subjective symptoms without parallel biological assessments.

(c) Limited long-term and mechanistic follow-up.

Few studies have assessed the sustainability of Tai Chi’s effects beyond immediate post-intervention. Notable exceptions include Cheung et al. [27] (12-month follow-up) and Irwin et al. [30] (15-month mechanistic follow-up), which demonstrated that psychological and inflammatory improvements could persist for months after cessation of structured practice. However, the majority of trials lacked follow-up beyond 8–12 weeks, leaving uncertain whether short-term symptom relief translates into durable behavioral or physiological resilience. Similarly, only a subset of studies [29,30,32,34] integrated biological endpoints such as cortisol, IL-6, CRP, or HRV alongside psychological measures, limiting mechanistic inference. Importantly, only one trial [22] conducted formal mediation analysis to test whether biomarker changes statistically mediated psychological improvements, underscoring the need for mechanism-driven study designs in future research.

(d) Publication bias and language restrictions.

An additional limitation concerns potential publication bias. The search was restricted to English-language, peer-reviewed publications, which may have excluded relevant studies published in Chinese, Korean, or other languages. Given that Tai Chi originates from China and a substantial proportion of research on this topic is conducted in East Asian countries, the exclusion of non-English literature may have introduced selection bias. Moreover, smaller studies reporting null findings may be less likely to be published, potentially inflating the observed effect sizes. Formal assessment of publication bias using funnel plots or Egger’s test was not feasible because fewer than 10 studies contributed to each meta-analytic estimate, in accordance with Cochrane Handbook recommendations [24].

(e) Population and contextual limitations.

The predominance of studies in East Asian and Western academic oncology

settings introduces cultural and healthcare-context bias. Although Tai Chi has cross-cultural applicability, variations in patients' prior familiarity with the practice, social support structures, and adherence behavior may influence outcomes. Moreover, nearly all included studies involved highly motivated volunteers, which may overestimate intervention adherence and underrepresent real-world feasibility in routine clinical care.

(f) Future research directions.

To consolidate Tai Chi's role within integrative oncology, future studies should prioritize large-scale, multicenter RCTs employing standardized Tai Chi protocols and consistent psychometric tools. Mechanism-driven designs are particularly needed to clarify the psychoneuroimmunological and neurocognitive pathways underlying observed benefits. Integrating biomarkers such as cortisol, IL-6, CRP, HRV, and transcriptomic markers (e.g., CTRA) alongside validated psychological outcomes (HADS, FACT-G, EORTC QLQ-C30) will enable bidirectional mapping between emotional regulation and biological recovery. Additionally, pragmatic trials that include diverse cancer types, stages, and sociocultural backgrounds will strengthen external validity. Future syntheses would also benefit from the inclusion of non-English databases (e.g., CNKI, Wanfang) to capture the full scope of Tai Chi research originating from East Asian settings.

In conclusion, while existing evidence suggests Tai Chi's multidimensional therapeutic potential, advancing the field requires rigorous, mechanism-oriented, and longitudinal research to delineate the causal pathways linking mind–body practice, inflammation, and psychosocial recovery in cancer survivors.

5. Conclusion

This systematic review highlights Tai Chi as a multidimensional form of therapeutic exercise that integrates motor control, neuromuscular coordination, and psychophysiological regulation to promote recovery in cancer populations. Synthesizing evidence from twelve cancer-specific quantitative studies, with partial meta-analysis of quality-of-life outcomes and narrative synthesis of anxiety and depression findings, Tai Chi shows promising potential in reducing anxiety, depression, and fatigue, while enhancing physical function, sleep quality, and overall QoL. A pooled random-effects meta-analysis of four RCTs yielded a moderate-to-large effect on global QoL (SMD = 0.69, 95% CI 0.44–0.95), and narrative synthesis of anxiety and depression outcomes indicated consistent directional benefits across trials, with individual effect sizes in the small-to-moderate range. These findings position Tai Chi within the broader continuum of exercise oncology as a low-to-moderate intensity activity that delivers both aerobic and autonomic conditioning through mindful movement rather than mechanical exertion.

Physiologically, Tai Chi may induce adaptive responses across multiple systems. The slow, continuous movements improve postural control, balance, and muscular endurance, while controlled breathing and attentional focus enhance parasympathetic activation and heart-rate variability, reflecting improved autonomic efficiency. Mechanistic evidence from cancer-specific trials and supplementary non-cancer studies included in this review suggests that such adaptations are associated with reductions in cortisol and pro-inflammatory cytokines (IL-6, CRP) and improvements in immune and metabolic function, consistent with a proposed exercise–immune–brain interaction. These integrated responses are consistent with the interpretation that Tai Chi acts not merely as gentle exercise but as a neuromotor training modality

with potential for restoring physiological homeostasis disrupted by cancer and its treatments. However, as only one included trial conducted formal mediation analysis, the causal pathways linking these biological changes to psychological improvements remain to be confirmed in adequately powered mechanistic studies.

Compared with aerobic or resistance training, Tai Chi uniquely bridges physical and psychological conditioning. Its emphasis on body awareness, rhythm, and controlled kinetic flow aligns with sport science principles of proprioceptive training and psychomotor learning. Unlike static meditative practices, Tai Chi requires coordinated movement sequences that challenge sensorimotor integration while maintaining attentional control, leading to concurrent enhancement of motor proficiency and emotional regulation. This dual engagement of mindful focus and kinetic feedback may explain the potentially favorable outcomes observed for fatigue, sleep, and emotional resilience in comparison with traditional exercise interventions, although direct head-to-head comparisons remain limited and generally underpowered for formal superiority testing.

Nevertheless, current evidence remains limited by small sample sizes, heterogeneous protocols, and inconsistent training doses. The diversity of outcome instruments across trials precluded meta-analytic pooling for anxiety and depression, and the small number of studies contributing to the quality-of-life meta-analysis limits the precision and generalizability of the pooled estimate. Publication bias could not be formally assessed due to the limited number of included studies. To advance Tai Chi as an evidence-based exercise modality within sport and rehabilitation science, future studies should adopt standardized training parameters—including session frequency, intensity, and progression—and employ objective performance metrics such as gait stability, electromyographic activity, and autonomic indices alongside psychosocial measures. Incorporating longitudinal, mechanism-oriented RCTs with formal mediation analyses and consistent psychometric instruments will clarify the dose–response relationship between Tai Chi training, physiological adaptation, and psychological recovery. The inclusion of non-English databases in future syntheses would also help capture the full scope of Tai Chi research originating from East Asian settings.

In conclusion, Tai Chi shows promise as a multidimensional mind-body exercise approach that may address both physiological and psychological rehabilitation objectives in cancer survivorship. Its dual influence on motor performance and emotional regulation exemplifies the emerging paradigm of integrative exercise oncology, where sport science principles intersect with behavioural medicine to support holistic, resilient recovery. While the current evidence is encouraging, large-scale, rigorously designed pragmatic trials with standardized protocols and adequate follow-up are needed before Tai Chi can be recommended as a standard component of oncology rehabilitation programs.

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Informed consent statement: Informed consent was not applicable because no human participants were directly recruited and all data were obtained from previously published studies.

Data availability statement: The data supporting the findings of this study were extracted from the published studies included in this systematic review and partial meta-analysis. Additional data are available from the corresponding author upon reasonable request.

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