

REVIEW ARTICLE

The Role of Yoga in Patients Undergoing Radiotherapy: A Review of Current Literature

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ABSTRACT

The role of yoga in patients undergoing radiotherapy(RT) for cancer treatment has garnered increasing interest recently. RT can result in significant side effects, such as fatigue, sleep disturbance, and decreased physical function, and yoga has shown potential in alleviating these effects. This narrative review aims to provide an overview of the potential benefits of yoga as a supportive care strategy for patients undergoing anticancer RT. We discuss relevant randomised studies and evidence supporting the effectiveness of yoga interventions, focusing on their impact in stress reduction, mood improvement, symptom management and overall well-being. By incorporating yoga into the treatment plan, healthcare professionals can enhance the holistic care of cancer patients and potentially improve treatment outcomes.

1. INTRODUCTION

Cancer still remains a global health issue that affects millions of people worldwide. According to recent statistics, the incidence of cancer is increasing, with an estimated 18.1 million new cases diagnosed per year and 9.6 million cancer-related deaths in 2018.^[1] These statistics highlight the significant impact of cancer on individuals and societies. Cancer patients often experience physical and psychosocial distress due to the disease and its treatment.^[2] As cancer survival rates improve due to medical breakthroughs, there is a growing emphasis on interventions that enhance the well-being of cancer patients.^[3,4]

Yoga is an ancient mind-body practice that originated in India over 5000 years ago, and it offers a holistic approach to health and well-being over time. It has gained prominence for its potential benefits in managing treatment-related symptoms and improving health outcomes in patients with cancer.^[5,6] While yoga is not a religion or belief system, it is considered a science that encompasses various practices and techniques.^[7] The exact mechanisms through which yoga supports physical and psychological improvement have yet to be

entirely understood. However, scientific evidence supports the belief that it down-regulates the hypothalamic-pituitary-adrenal axis and the sympathetic nervous system.^[8] The discipline of yoga encompasses a wide range of techniques, including physical postures (asanas), breathing exercises (pranayama), meditation, and ethical principles. These techniques work together to create a harmonious balance between the body, mind, and soul.

Today, yoga is used in many healthcare settings and can be accessed by patients and their carers regardless of their religious or cultural backgrounds. It is recognized for its ability to enhance bodily systems, improve posture, regulate sleep, and reduce stress and anxiety, among other benefits. Yoga has made a complimentary positive impact in managing various health conditions, including neurological diseases, heart and lung diseases, and chronic pain. There is also emerging evidence that yoga influences gene expression and epigenetic changes. Its holistic nature, addressing physical, emotional, and spiritual dimensions, makes it particularly relevant for individuals navigating the complexities of cancer treatment.

Yoga in cancer care involves integrating it as a supportive therapy to conventional treatments. It has been found to have beneficial effects on cancer-related symptoms such as fatigue, stress, sleep disturbances, and quality of life. Yoga provides a holistic approach that addresses the physical, emotional, and spiritual well-being of

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cancer patients.^[9] Several studies have explored the feasibility and benefits of yoga interventions for cancer patients. These studies have shown promising results, indicating that yoga is well-tolerated and can improve various outcomes, including physical functioning, fatigue, sleep quality, and psychological well-being.^[10,11] However, it is essential to note that the duration, schedules, and frequency of yoga interventions may vary across studies.^[12]

Two meta-analyses conducted by Buffart *et al.* and Harder *et al.* revealed the beneficial effects of practicing yoga.^[13,14] Yoga has been shown to reduce fatigue levels in women with breast cancer, improve sleep quality in cancer survivors, and enhance the overall quality of life in breast cancer patients.^[15-17] In addition, yoga has the potential to address potential side effects of cancer treatment, such as nausea, vomiting, and lymphedema.^[18,19] There is also evidence that yoga may improve immune function in cancer patients.^[20] Most published studies in this area have focused on women with breast cancer and patients undergoing chemotherapy.

The integration of yoga into cancer care requires a comprehensive understanding of the potential benefits and risks, as well as the preferences and needs of individual patients.^[21] Further research is needed to explore the specific mechanisms through which yoga exerts its effects on cancer-related symptoms and health outcomes.^[22]

Radiotherapy (RT) is a commonly employed treatment method in the management of various malignancies. It is an essential component of cancer therapy, and around half of all cancer patients undergo radiation therapy as part of their treatment regimen.^[23] By employing ionizing radiation, it aims to eradicate neoplastic cells while minimizing damage to surrounding healthy tissues. The primary objective of radiation therapy is to disrupt the ability of cancer cells to multiply and grow by damaging their DNA.^[24] In addition to damaging cancer cells, radiation therapy stimulates the immune system.^[25] While RT has demonstrated efficacy in tumor control and improved survival rates, it is often associated with acute and late side effects that can significantly impact patients' well-being and quality of life.^[26]

Common side effects of RT include fatigue, pain, skin reactions, gastrointestinal disturbances, and psychological distress, such as anxiety and depression.^[27,28] Moreover, depending on the specific irradiation site, patients may experience localized symptoms, including mucositis, dysphagia, or radiation pneumonitis, which can lead to impaired physical functioning, reduced social interactions, and diminished overall quality of life in this group.

As cancer patients undergoing RT grapple with numerous challenges, there is an escalating interest in uncovering complementary interventions that can alleviate treatment-induced side effects, augment coping mechanisms, and enrich health-related quality of life.^[29]

In their recent comprehensive review, Standish *et al.* illuminate the considerable advancements made in the realm of integrative oncology within the United States over the past three decades.^[30] The authors discuss the efficacy of mind-body modalities such as yoga in mitigating the distress linked with cancer diagnoses. These therapeutic approaches have been effectively incorporated into a diverse array of care programs, delivering palpable benefits to patients.

The review also explores the breakthroughs within the discipline of psychoneuroendocrinology, which have amplified our understanding of immune regulation and its consequential implications for cancer care. In addition, the study highlights the growing acknowledgment of the salience of spiritual health in cancer

patients. This recognition has led to the development of validated metrics designed to evaluate their overall well-being. With its holistic approach addressing physical, emotional, and spiritual dimensions, yoga has emerged as a promising adjunctive therapy in this context. However, the existing literature presents a heterogeneous landscape of findings, necessitating a review to understand yoga's impact and potential role in the care of patients receiving RT.

2. THE STUDY OBJECTIVE

The purpose of our review is to examine the existing literature on the impact of yoga on cancer patients and survivors who are undergoing RT. The review will specifically focus on the physical and psychosocial benefits of yoga and attempt to identify the mechanisms through which yoga can influence outcomes in patients receiving RT for cancer. By analyzing the available research, this review aims to provide a comprehensive understanding of the effects of yoga on this specific group of patients.

3. METHODOLOGY

A systematic literature search was conducted on multiple databases, including PubMed, Cochrane, Embase, and CINAHL to identify relevant articles that investigated the effects of yoga on cancer patients, survivors, and prevention strategies. The search was conducted using specific keywords and search terms to ensure the inclusion of articles relevant to our study. The identified articles were then screened based on their titles, abstracts, and full texts and relevant data were extracted. After removing duplicates, we limited our search to randomized clinical trials and comparative cohort studies that evaluated the impact of yoga on patients undergoing RT. Trials presented as conference proceedings but have yet to be published were excluded from the study. The review identified 11 studies that fit the criteria, and we discuss the results below.

4. RESULTS

Integrating holistic practices like yoga has become an area of keen interest in the intricate landscape of cancer treatment. Our review brings together findings from several trials examining the effects of yoga on patients undergoing RT. The results provide hope in the often-challenging cancer treatment journey and offer prospects for well-designed, robust, randomized controlled trials that measure short- and long-term outcomes across all cancer groups. Yoga, while not a cure-all, offers certain benefits that may enhance the overall treatment experience for patients. These include improved overall quality of life, Sleep Quality, fatigue levels, cortisol levels, immune response, oxidative stress, cytokine levels, DNA damage, and stress levels. The results of the studies are summarized in Table 1. We will discuss the studies in detail below.

In a randomized controlled trial by Chandwani *et al.*, the impact of yoga on the well-being of breast cancer patients undergoing RT was examined.^[31] Participants were allocated to yoga (YG, $n=53$), stretching (ST, $n=56$), or waitlist control groups (WL, $n=54$). The yoga cohort engaged in thrice-weekly sessions for 6 weeks during treatment. Assessment metrics included quality of life, fatigue, depression, sleep quality, and cortisol levels. The study's findings reveal that the yoga (YG) group exhibited improvements in their physical component scale scores compared to the waitlist (WL) group at both the 1-month and 3-month marks after undergoing radiation therapy (XRT) with p -values of 0.01 for both time points. Throughout

1, 3, and 6 months, the YG group demonstrated superior enhancements in physical functioning in comparison to both the ST and WL groups, with $P < 0.05$. The differences between the ST and WL groups were significant only at the 3-month mark ($P < 0.02$). At the time of completion of the XRT treatment, the YG and ST groups experienced a reduction in fatigue, with P -values below 0.05. However, there were no statistically significant group differences observed in mental health and sleep quality. Regarding the cortisol slope, it was most pronounced in the YG group when compared to both the ST and WL groups at the end of XRT ($P = 0.023$ and $P = 0.008$) as well as 1 month after XRT ($P = 0.05$ and $P = 0.04$).

In an RCT conducted by Vadiraja *et al.*, the potential impact of a structured yoga program on the quality of life and overall effect in early-stage breast cancer patients undergoing adjuvant RT was evaluated.^[32] The study comprised 88 Stages II and III breast cancer patients, participants who were randomly divided into two groups: One receiving daily 60-min yoga sessions ($n = 44$) and the other receiving brief supportive therapy once every 10 days ($n = 44$) before starting RT treatment. Assessments were conducted at baseline and after 6 weeks of RT treatment, using the European Organization for Research in the Treatment of Cancer-Quality of Life (EORTC QoL C30) functional scales and the Positive and Negative Affect Schedule. Results revealed significant differences across the two groups over time in terms of positive affect, negative affect, emotional function, and social function. The yoga group showed significant improvements in positive affect (effect size [ES] = 0.59, $P = 0.007$), emotional function (ES = 0.71, $P = 0.001$), and cognitive function (ES = 0.48, $P = 0.03$), along with a decrease in negative affect (ES = 0.84, $P < 0.001$) when compared to the control group.

In a Phase II randomized study, Ben-Josef *et al.* investigated the therapeutic potential of yoga in prostate cancer patients undergoing external beam radiation therapy.^[33] The patients were divided into two groups; the experimental group received bi-weekly yoga interventions, while the control group did not. The results revealed that the yoga group experienced significantly reduced fatigue levels and improved sexual health scores compared to the control group. While the quality-of-life measures presented a complex picture, with enhanced emotional, physical, and social scores but unaltered functional scores, the overall findings suggest that yoga interventions may offer positive impacts on fatigue and sexual health in prostate cancer patients during radiation therapy, as well as improvements in particular quality of life domains.

In a pilot randomized controlled trial undertaken by Kaushik *et al.*, the therapeutic potential of yoga in enhancing the quality of life and modulating the immune response in men undergoing treatment for prostate cancer was explored.^[34] The participants, comprising 42 men, were randomly allocated to either a yoga intervention or a control group. The yoga regimen, encompassing asanas, pranayama, and dhyana, was conducted bi-weekly for 12 weeks. Outcome measures involved assessments using the FACT-P questionnaire and examining cytokine levels. The study's findings indicated a significant enhancement in the quality-of-life domains, including physical, emotional, and functional well-being, among the yoga group compared to the controls. The immune response within the yoga group also exhibited a noteworthy shift, marked by a decrease in pro-inflammatory cytokines (TNF- α and IL-6) and an escalation in anti-inflammatory cytokine (IL-10) levels.

Banerjee *et al.* investigated the impact of an integrated yoga program on psychological stress and radiation-induced genotoxic stress in breast cancer patients receiving RT.^[35] Their study encompassed 68 patients, segregated into two cohorts: a yoga intervention group

and a control group. Remarkably, the yoga intervention group demonstrated a significant decrease in Hospital Anxiety and Depression Scale (HADS) scores, implying reduced perceived stress, anxiety, and depression. In contrast, the control group manifested an increase in HADS scores, indicating elevated levels of stress, anxiety, and depression. Furthermore, the yoga group revealed a decline in Perceived Stress Scale (PSS) scores, denoting diminished stress levels, unlike the control group, which exhibited no variation in PSS scores pre- and post-RT. When examining radiation-induced DNA damage, an increase was observed in both groups post-RT. However, the yoga group displayed marginally lower levels of DNA damage than the control group, hinting at a potential protective effect of yoga against radiation-induced DNA damage.

In a clinical trial by Vadiraja *et al.*, the therapeutic efficacy of an integrated yoga program was compared with brief supportive therapy in Stages II and III breast cancer outpatients receiving adjuvant RT.^[36] The study involved 88 participants and observed significant improvements in the yoga group across various parameters. Compared to the control group, those receiving yoga intervention had reduced self-reported anxiety, depression, perceived stress, and morning salivary cortisol levels. Further, the study also revealed a significant positive correlation between morning salivary cortisol levels and self-reported anxiety and depression, underscoring the potential role of yoga in mitigating psychological distress and modulating circadian patterns of stress hormones.

The 2016 study by Ratcliff *et al.* sought to discern the mediators and moderators of yoga's effects on women receiving RT for breast cancer.^[37] Utilizing an RCT design, the participants were stratified into yoga, ST, or waitlist control groups. The key findings revealed that yoga significantly mitigated depressive symptoms and sleep disturbances compared to the control groups. Furthermore, it was identified that shifts in spirituality and social support partially mediated the enhancement of depressive symptoms. The study also identified self-compassion and mindfulness as significant moderators of the association between yoga and sleep disturbances.

In another randomized controlled trial conducted by Rao *et al.*, the effects of an integrated yoga program on self-reported depression scores in breast cancer patients undergoing conventional treatment were evaluated.^[38] The study included 98 breast cancer patients randomly assigned to receive either yoga or supportive therapy. The patients underwent surgery followed by adjuvant RT, chemotherapy, or both. The study results showed that the yoga program significantly reduced self-reported symptoms of depression in breast cancer patients undergoing conventional treatment.

In a longitudinal cohort study conducted by Jain *et al.*, the long-term effects of yoga on stage II/III breast cancer patients undergoing chemotherapy and/or RT were investigated.^[39] The sample consisted of 96 patients, half of whom partook in a rigorous yoga regimen 5 days per week over a 48-week duration. The study utilized the EORTC-QLQ30 questionnaire to assess the quality of life and symptomatic scale and evaluated serum levels of inflammatory cytokines and oxidative stress markers at various intervals. Findings demonstrated a significant decline in the levels of IFN- γ , TNF- α , and MDA and a notable improvement in the quality of life and symptoms in the yoga group.

In a cohort study conducted by Micheletti *et al.*, the influence of yoga on stress, inflammation, and quality of life in stage 0 to III breast cancer patients receiving adjuvant RT was evaluated.^[40] The study involved

24 patients divided into two groups: a yoga group, which partook in bi-weekly yoga sessions during their RT, and a control group. Parameters such as quality of life, fatigue, sleep quality, cortisol levels, lymphocyte-to-monocyte ratios, and IL6, IL10, IL1RA, and TNF α were measured at different stages of treatment and follow-up. The study found a significant correlation between yoga practice and time, with the post-RT cortisol levels being notably lower in the yoga group compared to the control group. An interaction effect was also observed in the IL-1RA levels, indicating group-specific variations at specific intervals.

In a small two-arm non-randomised study, D'Cunha *et al.* explored the impact of yoga Nidra, a structured relaxation exercise, on stress levels in cervical cancer patients undergoing chemo-RT.^[41] The study involved 48 volunteers, split equally between a control group and an experimental group participating in yoga Nidra sessions during treatment. Stress levels were assessed before and after the radiation treatment. The results showed that participants who practiced yoga Nidra had significantly lower stress levels than those in the control group ($P < 0.0001$).

5. DISCUSSION

The precise molecular mechanisms underpinning the beneficial effects of yoga for cancer patients receiving RT remain elusive. However, a growing body of evidence suggests potential pathways. Research has indicated that yoga may attenuate radiation-induced genotoxic stress, as demonstrated by decreased DNA damage. In addition, yoga has been shown to modulate stress hormone circadian rhythms in early-stage breast cancer patients receiving adjuvant RT, suggesting a potential role in ameliorating psychological distress. Distinct molecular changes, such as alterations in global gene expression and DNA methylation, have also been proposed due to yoga interventions in a study investigating chronic low back pain.^[42]

Moreover, yoga interventions have been associated with regulating gene expression in various health conditions.^[43] The potential involvement of molecular pathways, such as the NGF pathway incorporating TNF- α and IL-6, has been suggested in oral cancer.^[44] Additionally, a reduction in inflammatory cytokine levels has been observed in breast cancer patients undergoing chemotherapy or RT who practice yoga, indicating a potential role in modulating the inflammatory response. These findings intimate that yoga may induce molecular changes conducive to stress reduction, DNA damage control, modulation of inflammatory and oxidative stress responses, hormone regulation, and enhancement of psychological well-being. Nevertheless, further research is imperative to explicate the specific molecular pathways implicated in yoga's beneficial effects on RT patients.

There is a compelling need for large-scale, randomized, controlled trials to substantiate these preliminary findings. Future research should also explore the long-term outcomes of yoga intervention in this patient population to truly gauge the sustainability of its potential benefits. The heterogeneity of yoga interventions underscores the need for standardization to ensure the comparability of results across different studies. The future studies could investigate the optimal timing, frequency, and duration of yoga interventions during RT treatment. In addition, examining the underlying mechanisms through which yoga exerts its effects and understanding the specific patient populations that might benefit the most would be valuable avenues for further investigation. Studies integrating technology-based platforms, such as virtual yoga sessions or smartphone applications, could enhance accessibility and adherence to yoga practices for RT patients. Exploring yoga's role in multidisciplinary cancer care and its potential synergies with other supportive therapies, such as mindfulness-based

interventions or exercise programs, also holds promise for improving patient outcomes.

Finally, we advocate for expanding research beyond breast and prostate cancer patients to understand yoga's potential in RT symptom management across various cancer types. These recommendations, we believe, will significantly contribute to establishing the efficacy of yoga in supportive cancer care and survivorship planning. By embracing the healing power of yoga, we can improve the lives of those affected by cancer and contribute to the broader goal of fostering a healthier, more resilient society.

6. CONCLUSION

The available evidence suggests that yoga could provide potential benefits for patients undergoing RT, specifically those with breast and prostate cancer. The enhancements in various aspects, such as quality of life, fatigue levels, cortisol levels, immune response, oxidative stress, cytokine levels, DNA damage, and stress levels, are promising. However, it is essential to acknowledge the limitations of the current research, which primarily consists of small-scale studies focusing on short-term outcomes. Therefore, further research is needed to understand the long-term implications better and to enhance the generalizability of these findings.

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All the authors contributed equally in design and execution of the article.

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This study not required ethical clearance as it is review study.

11. CONFLICTS OF INTEREST

Nil.

12. DATA AVAILABILITY

This is an original manuscript and all data are available for only review purposes from principal investigators.

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Table 1: Summary of studies that combined yoga in patients undergoing radiotherapy

Author and year of publication	Sample size	Study aim	Methods and patient selection	Conclusion
Chandwani <i>et al.</i> JCO 2014	163	3 armed RCT comparing yoga thrice weekly versus Stretching versus waitlist control group over 6 weeks	Breast cancer patients assessing self-reported aspects of QoL, fatigue, depression and sleep and tested cortisol levels at 1, 3 and 6 months	The yoga cohort had a significantly higher gain in physical functioning scores vs the stretch and waitlist groups at 1, 3 and 6 months. Fatigue was lower in both the interventional groups at the end of RT and lasted 1 month later and the cortisol drop was more apparent in the former group as well
Vadiraja <i>et al.</i> Complementary Therapy 2009	88	Equally split groups assigned Yoga program versus a control group	In Stage II and III Breast cancer patients undergoing adjuvant radiation therapy, overall emotional effect (PANAS) and QOL were measured	The Yoga group showed significant improvements in positive affect, emotional function, cognitive function and decrease in negative affect.
Ben-Josef <i>et al.</i> IJROBP 2017	50	Phase 2 study looking at twice weekly yoga versus a control group who had none	Prostate Cancer assessing fatigue, QoL and Sexual health measures	Yoga group had a significantly lower fatigue and higher sexual health scores and QoL scores for emotional, physical and scores were better but not for functional scores
Kaushik <i>et al.</i> Prostate Cancer Prostatic Dis. 2022	42	Pilot RCT which needed further research with a larger sample size and longer follow up	Prostate Cancer, 1 h yoga session (Physical postures, breath work and meditation) twice weekly for 3 months versus a control group. Functional Assessment of Cancer Therapy-Prostate (FACT-P) and cytokines levels of tumour necrosis factor-alpha and interleukin-6 and Interleukin-10	Yoga leads to significantly better physical, emotional and functional wellbeing scores with reductions in pro-inflammatory (TNF α and IL-6) and increases in anti-inflammatory cytokines (IL-10) and thus an overall positive impact on the immune system
Banerjee <i>et al.</i> Integr Cancer Ther 2007	68	Integrated Yoga program versus control arm assessing Hospital Anxiety and Depression Scale (HADS) scores and Perceived Stress Scale (PSS) scores	Breast cancer Assessment of both psychological distress and Radiation-induced DNA damage	The integrated Yoga program group had significantly less HADS score whilst the control group a higher score. Although the PSS scores were also lower in the yoga group it was unchanged in the control group. Both groups had lower DNA damage which was proportionately lower in the yoga group and may suggest a protective effect
Vadiraja <i>et al.</i> Integr Cancer Ther 2009	88	Equally split groups assigned Yoga program versus a control group	Breast cancer patients undergoing adjuvant radiation therapy Diurnal salivary cortisol measurements 3 days before and after RT with before and 6 weeks after RT self-ratings of anxiety, depression and stress assessments	Decreased Anxiety, depression and stress levels with corresponding lowered morning and mean cortisol levels in the yoga arm
Ratcliff <i>et al.</i> Integr Cancer Ther 2016	163	RCT 3 arm trial of Yoga versus Stretching versus Waitlist control group	Breast Cancer QoL measures using the SF-36 mental and physical components at different times	This study showed that women with higher baseline depressive symptoms or sleep disruption report higher mental component scores (MCS) at 3 months and also the Physical component scores (PCS) in the yoga intervention group compared to the control group.
Rao <i>et al.</i> Indian J Palliative Care 2017	98	RCT Randomly assigned to received and integrated yoga program versus supportive therapy	Breast cancer patients used a self-reported depression scores after surgery followed by adjuvant radiotherapy or chemotherapy	Significant reduction in depressive symptoms in the yoga group
Jain <i>et al.</i> Cureus 2023	96	2-arm study for those already practicing yoga long term, 5 days a week for 48 weeks versus those who do not	Breast cancer patients- stage 2-3 undergoing chemotherapy with or without radiotherapy Using the EORTC-QLQ30 to evaluate QoL and symptoms as well as serum inflammatory cytokines and oxidative stress levels	Notable improved in QoL and symptom scale in the interventional arm as well as lower levels of IFN-g and TNF α and MDA
Micheletti <i>et al.</i> Technical Innovations & Patient Support in Radiation Oncology 2022	24	2-arm study of twice weekly yoga during RT versus control group	Adjuvant breast cancer patients-Stage 1-3 Looked at the impact of yoga on stress, inflammation and QoL, fatigue, sleep, cortisol, Lymphocyte to monocyte levels and inflammatory markers, TNF α , IL-6, IL-10 and IL-1RA	Post RT patients in the yoga arm had lower cortisol levels and lowered pro-inflammatory signals of IL-1RA
D'cunha <i>et al.</i> Middle East Journal of Cancer 2021	48	2-arm randomized study, equal split into yoga Nidra and control arms	Cervical cancer patients undergoing definitive Radio-chemotherapy Exploration of Yoga Nidra (structured relaxation). Stress levels were assessment before and after treatment	Highly statistical benefit of lowered stress levels in the experimental versus the control group ($P < 0.0001$)