

Yoga into Cancer Care: A Review of the Evidence-based Research

Abstract

To cope with cancer and its treatment-related side effects and toxicities, people are increasingly using complementary and alternative medicine (CAM). Consequently, integrative oncology, which combines conventional therapies and evidence-based CAM practices, is an emerging discipline in cancer care. The use of yoga as a CAM is proving to be beneficial and increasingly gaining popularity. An electronic database search (PubMed), through December 15, 2016, revealed 138 relevant clinical trials (single-armed, nonrandomized, and randomized controlled trials) on the use of yoga in cancer patients. A total of 10,660 cancer patients from 20 countries were recruited in these studies. Regardless of some methodological deficiencies, most of the studies reported that yoga improved the physical and psychological symptoms, quality of life, and markers of immunity of the patients, providing a strong support for yoga's integration into conventional cancer care. This review article presents the published clinical research on the prevalence of yoga's use in cancer patients so that oncologists, researchers, and the patients are aware of the evidence supporting the use of this relatively safe modality in cancer care.

Keywords: *Cancer, complementary and alternative medicine, integrative medicine, meditation, mindfulness-based stress reduction, yoga*

Introduction

Cancer is one of the most feared diseases. Starting from the diagnosis of cancer, its progression (i.e., metastasis to bone and organs), adverse effects of its treatment (chemotherapy, radiation, and surgery), and diagnostic procedures (biopsies and radiological diagnostic scans) can cause physical, psychological, and emotional problems affecting patients' quality of life (QOL).^[1-9]

The statistics of new cancer cases and cancer-related mortality is scary. According to the 2016 report of the American Cancer Society, more than 1.6 million new cancer cases were diagnosed each year,^[10] about 32.6 million people were living with cancer worldwide, and the number has been increasing with time. It is estimated that about 33% of women and 50% of men would develop cancer during their lifetime; about 15% of all deaths worldwide would be attributed to cancer, about 77 million people worldwide would die of cancer, and it would surpass heart diseases.^[10,11]

With advances in diagnostic methods and improved treatment strategies, it is expected

that the number of cancer survivors will continue to increase and pose a great challenge to health care system.^[12-17]

Despite the availability of powerful technology and strong and targeted medicines, the desired therapeutic success in cancer care and other chronic diseases remains an elusive goal for the modern medicine. In addition, the conventional medical interventions are expensive and associated with undesirable toxicities. The patients, therefore, may turn to nonconventional therapies, e.g., complementary and alternative medicine (CAM).^[18] Increasing interest in CAM and demands from the public, medical professionals, media, and government agencies had led the National Institute of Health in 1998 to establish the National Center for Complementary and Alternative Medicine (NCCAM) to explore those practices that are not currently considered to be a part of conventional (or main stream) medicine practiced, especially by MDs in the USA such as (i) whole medical systems (Ayurveda, Chinese traditional medicine, homeopathy, and naturopathy); (ii) mind-body medicine (yoga, meditation, relaxation,

**Ram P Agarwal,
Adi Maroko-Afek**

*Department of Medicine,
Division of Oncology, Miller
School of Medicine, University
of Miami, Miami, Florida, USA*

Address for correspondence:

*Dr. Ram P Agarwal,
Division of Oncology,
Miller School of Medicine,
University of Miami, Miami,
Florida 33136, USA.
E-mail: ragarwal@med.miami.
edu, ram33156@gmail.com*

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visualization/imagery, cognitive therapy, aromatherapy, dance, healing touch, hypnosis, music, art, prayer, sleep promotion, support groups, etc.); (iii) biologically based practices (dietary supplements, herbal products, shark cartilage, etc.); (iv) manipulative and body-based practices: acupressure, acupuncture, chiropractic, massage, osteopathic manipulation; and (v) energy medicines (Qi gong, Reiki, therapeutic touch, electromagnetic fields, and alternating-current or direct-current fields). In other words, a group of diverse medical and healthcare systems, products, and practices that are “not usually taught in medical schools, not available in most hospitals, clinics, and private practices, and often not reimbursed or otherwise routinely accessible.”^[19]

The definition of CAM, however, has been changing over time. Since some of the whole medical systems – Ayurveda, homeopathy, naturopathy, and Chinese traditional medicine, are used as one of the main medical practices in India and China; only a few patients in the USA (3%–6%) make use of them. These have now been dropped from the list of CAM and the NCCAM has reincarnated with a new name, The National Center for Complementary and Integrative Health “NCCIH.”^[20] The term “integrative medicine” is becoming more popular. The commonly used current terminology is complementary medicine (therapies used in conjunction with conventional medicine); alternative medicine (therapies used in place of conventional medicine); and integrative medicine (use of evidence-based CAM practices with conventional medicine).

The use of CAM is significantly increasing over the years. About 38% persons in the USA are using CAM for managing pain, arthritis, cardiovascular diseases, cancer, and psychological and emotional problems such as stress, anxiety, and depression, at the cost of approximately \$40 billion.^[21-24] The use of integrative medicine, particularly in cancer care, is so popular that a number of medical schools and cancer centers are now offering programs in integrative medicine to their patients. “Integrative oncology” in particular is emerging as a new discipline in cancer centers.

Western scientists are now moving away from the matter-based approach that they had been practicing and realizing the importance of mind–matter relationship. In their quest to understand the subtler dimensions of the universal laws and gain new insights in the mind–matter relationship, they are turning to understand the wisdom and practices of the East.

Yoga, the mind–body medicine of CAM, is comprised of a wide range of techniques, which gradually harmonizes the body and mind as compiled by Patanjali in his *Yoga Sutras*.^[25] Because of its health-related benefits, yoga has been an integral part of Ayurveda, the oldest and indigenous medical system practiced in India and described in *Charak Samhita* and *Susruta Samhita*.^[26,27] Yoga (meaning union

or to join) has been used by Hindus and Buddhists for thousands of years for maintaining good health as well as a spiritual practice (union of the individual self with the universal self, salvation). During the last five decades, there has been a worldwide interest in yoga practices. In its various forms and for various reasons (physical and mental health-related benefits), yoga is now practiced worldwide by millions of people irrespective of their age, gender, race, religion, and nationality. The surging interest in yoga may be appreciated by the fact that, in the year 2012, more than 20 million Americans were using yoga spending more than 10 billion dollars annually on yoga classes and products, and since 2011, about 200 titles are added each year on the use of yoga in different medical conditions.^[28-30] Integration of yoga with conventional cancer care is a “patient-centered approach that nurtures the physical, emotional, and spiritual wellbeing of cancer patients.”^[31] Despite a number of reports and reviews supporting efficacy of yoga in health care, the awareness and integration of yoga in conventional healthcare remain limited.^[24] Therefore, the main purpose of this review is to familiarize cancer patients and their caregivers (oncologists, nurses, family members, and patients) with the research evidence of the beneficial effects of yoga and to encourage more scientifically focused research so that yoga therapy is fully recognized and integrated into cancer therapeutic programs.

Methods

A search of English language literature published through December 15, 2016, on the use of yoga in cancer was conducted using the National Library of Medicine electronic database, PubMed. An advanced search using Boolean operators (i.e., “AND,” “OR,” and “NOT”) was performed using the medical subject heading terms and the keywords: yoga, meditation, *pranayama*, breathing exercises, mindfulness-based stress reduction, and cancer. The primary results obtained were further analyzed using filters, i.e., reviews, clinical trials, and others. Following initial independent dual examination of the titles and the abstracts of the clinical trials, the articles that were found irrelevant, e.g., protocol developments, telephone surveys, and using Qi gong (even though it may have some elements of breathing exercises), were excluded from further analysis. Additional secondary references were obtained from the reviews and other publications.

Results

Of a total of 864 articles identified through the electronic database search, 203 articles were clinical trials [Figure 1]. After examination of the titles and the abstracts, 138 studies met the inclusion criteria - 28 single armed trials [Table 1]^[32-59] and 110 randomized and nonrandomized controlled trials: 18 from 1996 to 2008 [Table 2],^[60-77] 34 from 2009 to 2012 [Table 3],^[78-111] and 58 from 2013 to 2016 [Table 4].^[112-169]

A total of 10,660 patients who participated in these studies had had breast cancer, colorectal cancer, leukemia, lymphoma, lung cancer, pediatric cancer (unspecified), prostate cancer, hematopoietic stem cell transplant patients, and others [Tables 1-4].

The measures included almost all the symptoms and side effects listed in Table 5. In addition, the effect of yoga was reported on the telomere length, telomerase activity, T-cell

subsets, signaling pathways of inflammatory transcription genes, cytokines, nuclear factor kappa B, and cAMP response element binding protein.^[77,131] In the vast majority of the studies, the yoga intervention was found to be beneficial and yielded positive effect on all the measures.

Even though the study protocols used different types and styles of yoga – *Hatha yoga, Iyengar yoga, Dru, Vini, restorative yoga, etc.*, [Tables 1-4], all of them were slight variations of Patanjali's *Ashtanga Yoga (asanas, pranayamas, and dhyana)* tailored to the patients' need and/or investigators' convenience. The duration and frequency of yoga practices also differed widely in different studies. The interventions were administered either to a group or individually by an experienced yoga instructor at the study site and/or practiced at home with the help of DVDs provided by the investigators. The effect of yoga was examined on almost all the cancer-related symptoms and treatment-related side effects listed in Table 5 and on the markers of immunity, inflammation, stress, etc.

The studies were conducted in 20 countries from five continents (Australia, Asia, Europe, North America, and South America). Majority of the studies had been done in the USA ($n = 61$), followed by Canada ($n = 21$), India ($n = 9$), UK ($n = 8$), Sweden ($n = 6$), Germany ($n = 5$),

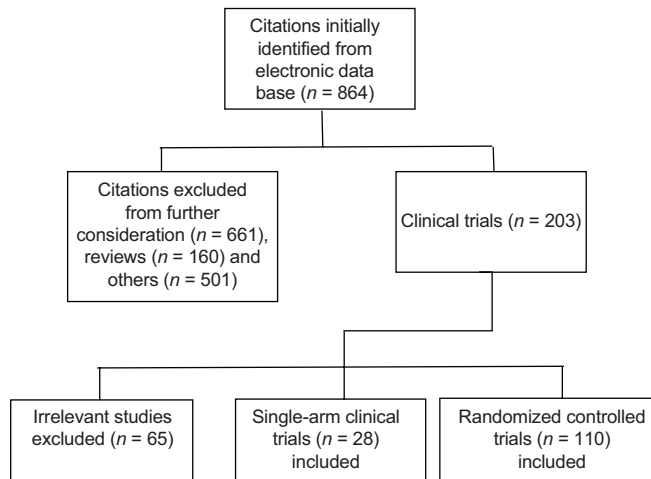


Figure 1: Flow diagram of included and excluded studies

Table 1: Summary of single-armed clinical trials of yoga in cancer patients from 2001-2016

Number	Reference	Country	Number of patients	Interventions	Measures	Results
Cancer type						
1	Saxe <i>et al.</i> , 2001 ^[32]	USA	10 Prostate cancer	10 week Diet and MBSR	PSA	Decreases the rate of PSA increase
2	Carlson <i>et al.</i> , 2004 ^[33]	Canada	59/10 BC/prostate cancer	MBSR 8-weekly, 90 min group session with a maximum of 15 participants each	QOL, salivary cortisol, plasma DHEAS, and salivary melatonin	Significant improvements in QOL, stress, and sleep quality
3	Carlson and Garland, 2005 ^[34]	Canada	63 Heterogeneous	MBSR (Kabat-Zinn) 8-week	Sleep quality, mood, stress, and fatigue	Sleep disturbance was significantly reduced, sleep quality improved, significant reduction in stress, mood disturbance, and fatigue
4	Carson <i>et al.</i> , 2007 ^[35]	USA	13 Metastatic BC	Yoga of awareness program 8 weeks/once a week	Pain, fatigue, distress, invigoration, acceptance, and relaxation	Significant increases in invigoration and acceptance
5	Carlson <i>et al.</i> , 2007 ^[36]	Canada	14 BC	MBSR (relaxation, meditation, gentle yoga) 8 weeks	Demographic, health behaviors, QOL, mood, stress symptoms, salivary cortisol levels, immune cell counts, intracellular cytokine production, BP, and HR	Enhanced QOL, decreased stress symptoms, reduced stress and mood disturbance, decreased BP

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Table 1: Contd...

Number	Reference	Country	Number of patients Cancer type	Interventions	Measures	Results
6	Bauer-Wu <i>et al.</i> , 2008 ^[37]	USA	20 HSCT	Mindfulness meditation (one-on-one sessions plus daily practice using a 17-min meditation CD)	Physical and psychological symptoms, anxiety, mood, and pain	Significant decreases in heart and respiratory rates
7	Kieviet-Stijnen <i>et al.</i> , 2008 ^[38]	Netherlands	47 Cancer	MBSR: Kabat-Zinn	QOL, joy in life, mood disturbances (depression, anger, vigor, fatigue, and tension), meaning in life, and physical symptoms	Increased wellbeing and ability to cope with stress
8	Witek-Janusek <i>et al.</i> , 2008 ^[39]	USA	14 BC	MBSR: Kabat-Zinn	Immune function, QOL, and coping	Re-established their NK cell activity and cytokine production, reduced cortisol levels, improved QOL, and increased coping effectiveness
9	Ando <i>et al.</i> , 2009 ^[40]	Japan	28 BC	Mindfulness-based meditation	Anxiety, depression, and spiritual wellbeing and the relationships to growth, appreciation, and pain	Found effective for anxiety and depression. Spiritual wellbeing is related to anxiety and depression, growth, and pain
10	Fang <i>et al.</i> , 2010 ^[41]	USA	24 Heterogeneous cancers	MBSR: Kabat-Zinn 8 weeks	Changes in psychosocial and immunologic measures	Significant improvements in anxiety, distress, QOL, and wellbeing were associated with increased NK-cytolytic activity and decreased levels of CRP
11	Ulger and Yağlı, 2010 ^[42]	Turkey	20 BC	Yoga (<i>asanas</i> , <i>pranayama</i> , meditation)	QOL, stress, and anxiety level	Yoga was valuable in helping to achieve relaxation and diminish stress, helped cancer patients to perform daily and routine activities, and increases the QOL
12	Fox <i>et al.</i> , 2011 ^[43]	USA	22 Women with pelvic pain	Mindfulness meditation	Daily pain scores	Significant improvement in daily pain, physical function, mental health, and social function
13	Matousek <i>et al.</i> , 2011 ^[44]	Canada	33 BC	MBSR	Cortisol and stress	Positive effect on cortisol levels, significant improvements in stress levels
14	Thomas and Shaw, 2011 ^[45]	Canada	10 BC with treatment-related arm morbidity	Gentle Iyengar yoga 6 weeks	Yoga as a healing therapy for women under BC treatment	Physical, emotional, and spiritual benefits
15	Galantino <i>et al.</i> , 2012 ^[46]	USA	10 Postmenopausal women with stage I-III BC patients with AIAA	90 min yoga, twice/week, for 8 weeks, and continued at home	Pain, physical fitness (energy, flexibility, and function)	Improved QOL and reduced AIAA. Increased physical fitness and reduced stress/anxiety

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Number	Reference	Country	Number of patients Cancer type	Interventions	Measures	Results
16	Fouladbakhsh <i>et al.</i> , 2013 ^[47]	USA	9 I-III stage NSCLC	Standardized VY 8 weeks/40 min week	Effects on sleep, mood, salivary cortisol levels, and QOL	QOL significantly improved; salivary cortisol levels decreased over time
17	Garland <i>et al.</i> , 2013 ^[48]	Canada	268 heterogeneous cancer patients (breast, blood, and colorectal cancers)	MBSR program that included meditation	Mindful attention, stress, mood disturbance	Increase in mindful attention and decrease in mood disturbance and stress
18	Nakau <i>et al.</i> , 2013 ^[49]	Japan	22 Breast and lung cancer	Forest, horticultural, yoga, meditation, and support group therapy Once per week for 12 weeks	Spiritual wellbeing, QOL, fatigue, psychological symptoms, anxiety, and NK cell activity	Significant improvement in functional wellbeing and spiritual wellbeing. Improved QOL, reduced fatigue and some aspects of psychological symptoms, and increased NK cell activity
19	Van Puymbroeck <i>et al.</i> , 2013 ^[50]	USA	18 BC	8-week yoga intervention	Health promoting symptoms (physical, social, and mental health)	Improvement in all measures
20	Ross Zahavich <i>et al.</i> , 2013 ^[51]	Canada	22 (15 prostate cancer and 7 support persons)	14 weeks (7 weeks class-based yoga program, 7 weeks self-selected activity)	Physical activity, QOL, fatigue, social support, fitness, stress, and mood	All improved
21	Stafford <i>et al.</i> , 2013 ^[52]	Australia	55 BC	8 weekly 2 h sessions of a modified Kabat-Zinn program	Distress, QOL, posttraumatic growth	Significant improvement for distress, QOL, mindfulness, and posttraumatic growth
22	Sudarshan <i>et al.</i> , 2013 ^[53]	Canada	17 Stage I-III postoperative BC	1 h weekly 12 yoga sessions	Anxiety, depression, and physical health	Improvement in all the measures
23	Charlson <i>et al.</i> , 2014 ^[54]	USA	46 BC, poor minority women	20-week-guided meditation-based stress reduction program in 2 phases: First, 8-weekly 90 min group sessions; second, 12 sessions of cognitive-affective-behavioral learning program	QOL	42 patients completed follow-up Improved QOL Posttraumatic stress reduced significantly
24	Fisher <i>et al.</i> , 2014 ^[55]	USA	6 BC with lymphedema	1 h weekly for 8 weeks (live sessions 2 and 1 home-recorded session)	Grip strength, arm volume, arm function, QOL	A significant decrease in arm volume Changes in QOL, hand grip strength, and arm function but not significant
25	Fouladbakhsh <i>et al.</i> 2014 ^[56]	USA	7 patients who completed initial treatment for Stage I-III NSCLC	40 min/week for 14 weeks intervention, Vinyasa yoga program was specially developed for this study Assessments were done at 3 months, preintervention, 8 weeks of yoga classes, and 3-week postintervention	Sleep quality, mood, QOL, and salivary cortisol	Mood, sleep efficiency, and QOL improved significantly. Salivary cortisol levels decreased over time

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Number	Reference	Country	Number of patients Cancer type	Interventions	Measures	Results
26	Wurz <i>et al.</i> , 2014 ^[57]	Canada	8 pediatric cancer patients, (4 male, 4 female)	12-week yoga intervention, 2 times/ week Follow-up at 3 and 6 months poststudy	HRQL, physical fitness, and physical fitness outcome level (PAL)	Significant improvement in functional mobility, Hamstring mobility, and total PAL
27	Diorio <i>et al.</i> , 2015 ^[58]	Canada	11 children receiving intensive chemotherapy (AML, relapsed lymphoblastic leukemia, Burkitt's lymphoma/ leukemia, or about to receive HSCT)	Yoga 3 times/week for 3 weeks. Changed to 4-5 times weekly. Yoga included focusing, balancing, and <i>Savasana</i> (corpus pose)	Feasibility, QOL	10 of 11 patients completed the study, thus proving the feasibility Yoga reduced fatigue
28	Hooke <i>et al.</i> , 2016 ^[59]	USA	18 patients, 13 completed study Children aged 10-18 years (leukemia, lymphoma, solid tumors, CNS tumors)	6-week yoga intervention (standing poses, stretching, meditation, warm-up poses, balancing and resting poses, modified according to need) Assessment at before and 1, 6, and 11 weeks during the study	General fatigue, sleep/rest fatigue, cognitive fatigue	At 6 weeks, fatigue and sleep were stable No change in balance Decrease in anxiety

BC=Breast cancer, MBSR=Mindfulness-based stress reduction, PSA=Prostate-specific antigen, QOL=Quality of life, DHEAS=Dehydro-epiandrosterone sulfate, BP=Blood pressure, HR=Heart rate, CRP=C-reactive protein, AIAA=Aromatase inhibitor-associated arthralgia, VY=*Vinyasa* Yoga, NSCLC=Non-small cell lung cancer, HEQL=Health related quality of life, PAL=Physical activity level, AML=Acute myeloid leukemia, CNS=Central nervous system, HSCT=Hematopoietic stem cell transplantation

Table 2: Summary of randomized controlled trials of yoga in cancer patients from 1996-2008

Number	Reference	Country	Number of patients (intervention: control) Cancer type	Intervention	Measures	Results
1	Corner <i>et al.</i> , 1996 ^[60]	UK	20 (10:10) Small cell and NSCLC	Weekly sessions/3-6 weeks using counseling, breathing re-training, relaxation and teaching coping, and adaptation strategies	Breathlessness, distress caused by breathlessness, functional capacity, ability to perform activities of daily living, anxiety, and depression	Improvements in median scores on all measures
2	Specia <i>et al.</i> , 2000 ^[61]	Canada	90 73 females, 17 males Heterogeneous group	1.5 h/week meditation, 7 week	Mood symptoms of stress inventory	Significantly lower scores on total mood disturbance and subscales of depression, anxiety, anger, and confusion and more vigor than control subjects. The treatment group also had fewer overall symptoms of stress; fewer cardiopulmonary and gastrointestinal symptoms;

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Table 2: Contd...

Number	Reference	Country	Number of patients (intervention: control) Cancer type	Intervention	Measures	Results
3	Carlson <i>et al.</i> , 2001 ^[62]	Canada	89 (not specified) 72 women and 17 men 26 different types of cancer	1.5 h/week, 7 weeks, mindfulness meditation, plus daily home meditation practice	POMS and SOSI pretreatment, posttreatment, and 6-month follow-up	less emotional irritability, depression, and cognitive disorganization; and fewer habitual patterns of stress. Overall reduction in total mood disturbance was 65%, with a 31% reduction in symptoms of stress Significant decrease on the POMS and SOSI total scores and most subscales, indicating less mood disturbance and fewer symptoms of stress, and these improvements were maintained at the 6-month follow-up Female gender and more education were associated with higher initial SOSI scores, and improvements on the SOSI were predicted by more education and greater initial mood disturbance
4	Hebert <i>et al.</i> , 2001 ^[63]	USA	157 (51:50:56) Intervention, nutrition, and usual care BC	MBSR 15 sessions	Dietary fat, complex carbohydrates, fiber, and body mass	No change in MBSR group
5	Fagevik <i>et al.</i> , 2002 ^[64]	Sweden	70 (36:34) Esophagus	Comparison of IR-PEP and/or CPAP	Pulmonary insufficiency after thoracoabdominal resection	Artificial ventilation (CPAP) is preferred over IR-PEP
6	Targ and Levine, 2002 ^[65]	USA	181 (93:98) BC	Meditation, imagery, and rituals	QOL, depression, anxiety, spiritual wellbeing	Decreased avoidance, higher satisfaction, and fewer dropouts
7	Shapiro <i>et al.</i> , 2003 ^[66]	USA	63 (31:32) Stage II BC, cancer-free at the time of the study	MBSR, 6-weekly 2-h sessions and one 6-h silent retreat	QOL, psychological distress, sense of control, anxiety, depression, sense of coherence, and worry	Improved quality of sleep strongly related with distress
8	Cohen <i>et al.</i> , 2004 ^[67]	USA	38 (19:19) Lymphoma	Tibetan yoga	Feasibility and sleep quality	The program was feasible and improved sleep-related outcomes
9	Hidderley and Holt, 2004 ^[68]	UK	31 (16:15) BC (early stage)	AT - meditation by hypnosis	HADSs and T- and B-cell markers	Improvement in HADS and increase in immune response
10	Kim and Kim, 2005 ^[69]	South Korea	35 (18:17) HSCT	Relaxation breathing exercise 30 min daily for 6 weeks	Anxiety, depression	Improved anxiety and depression levels

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Table 2: Contd...

Number	Reference	Country	Number of patients (intervention: control) Cancer type	Intervention	Measures	Results
11	Kim and Kim, 2005 ^[70]	South Korea	35 (18:17) HSCT	Relaxation breathing exercise 30 min daily for 6 weeks	Fatigue	Intervention group had greater decrease in fatigue
12	Culos-Reed <i>et al.</i> , 2006 ^[71]	Canada	38 (20:18) BC	7-week yoga program	Cancer-related symptoms and treatment-related side effects	Significant improvement QOL, emotional function, and diarrhea. Further, there was a trend of expected improvements in emotional irritability, gastrointestinal symptoms, cognitive disorganization, mood disturbance, tension, depression, and confusion
13	Monti <i>et al.</i> , 2006 ^[72]	USA	111 (56:55) Women with a variety of cancers	MBAT developed for cancer patients	Symptoms of distress and QOL	Decreased symptoms of distress, health-related QOL
14	Banerjee <i>et al.</i> , 2007 ^[73]	Singapore	68 (35:33) BCS	Integrated yoga program	Psychological stress in radiation-induced genotoxicity, stress	A significant decrease in HADS. Further, decrease was noted in PSS. Posttherapy, DNA damage in the yoga group was slightly less
15	Moadel <i>et al.</i> , 2007 ^[74]	USA	120 (80:40) BC	12-week yoga intervention	QOL, fatigue, distressed mood, and spiritual wellbeing	Favorable outcomes for QOL, emotional wellbeing, social wellbeing, spiritual wellbeing, and distressed mood
16	Raghavendra <i>et al.</i> , 2007 ^[75]	India	62 (28:34) BC	Integrated yoga program	Primary: MANE. Secondary: anxiety, depression, QOL, distressful symptoms, and treatment-related toxicity	A significant decrease in postchemotherapy-induced nausea frequency, nausea intensity, and intensity of anticipatory nausea and anticipatory vomiting. In addition, a significant positive correlation between MANE scores and anxiety, depression and distressful symptoms
17	Sephton <i>et al.</i> , 2007 ^[76]	USA	91 (51:40) Fibromyalgia	2.5 h/weekly; 8 sessions; mindful-meditation	Somatic and cognitive symptoms of depression	A significant improvement in the depressive symptoms
18	Rao <i>et al.</i> , 2008 ^[77]	India	98 (45:53) Patient diagnosed with operable BC	An “integrated yoga program” (<i>pranayama</i> , breathing exercises, and yogic relaxation techniques)	Natural killer cells, anxiety, depression, QOL, cytokines, and mood states	Significant decrease in stress, depression, symptom severity, distress and improvement in QOL. Lesser decrease in T-lymphocyte subsets and serum IgA

BC=Breast cancer, BCS=Breast cancer survivors, HADS=Hospital Anxiety and Depressions, MBSR=Mindfulness-based stress reduction, QOL=Quality of life, POMS=Profile of mood states, SOSI=Symptoms of Stress Inventory, CPAP=Continuous positive airway pressure, IR-PEP=Inspiratory resistance-positive expiratory pressure, HSCT=Hematopoietic stem cell transplant, MBAT=Mindfulness-based art therapy, MANE=Morrow Assessment of Nausea and Emesis, NSCLC=Non-small cell lung cancer, AT=Autogenic training, PSS=Perceived Stress Scale

Table 3: Summary of randomized controlled trials of yoga in cancer patients from 2009 to 2012

Number	References	Country	Number of patients (intervention: control) Cancer type	Intervention	Measures	Results
1	Carson <i>et al.</i> , 2009 ^[78]	USA	37 (17:20) BC, IA-III B	8-week yoga of awareness program	Menopausal symptoms, hot flashes, joint pain, fatigue, sleep disturbance at pretreatment, posttreatment, and 3-month follow-up	Beneficial effects of yoga for hot flashes and other menopausal symptoms
2	Danhauer <i>et al.</i> , 2009 ^[79]	USA	44 (22:22) BC	70 min weekly 10 weeks, restorative yoga	Self-reported emotional, health-related QOL, and symptoms	Significant improvement in emotional outcomes and fatigue
3	Djuric <i>et al.</i> , 2009 ^[80]	USA	24 (12:12) Obese BC patients	Spiritual counseling and meditation	Spiritual wellbeing and dietary quality	Both were positively affected
4	Lengacher <i>et al.</i> , 2009 ^[81]	USA	84 (41:43) 0-III BC	6-week MBSR	Depression, anxiety, perceived stress, fear of recurrence, optimism, social support, and physical QOL	Lower levels of depression, anxiety, and fear of recurrence and increase in energy and physical functioning
5	Nidich <i>et al.</i> , 2009 ^[82]	USA	130 (64:66) II-IV stage BC	Transcendental meditation	FACT-B, FACIT-SP, and SF-B mental health and vitality scales, every 6 months over an average of 18-month intervention	Significant improvement in overall QOL, emotional wellbeing, social wellbeing, and SF-36 mental health
6	Ramachandra <i>et al.</i> , 2009 ^[83]	UK	46 (23:23) 22 BC 24 men metastatic prostate	Mental awareness program	Anxiety, depression, wellbeing, and QOL	The intervention was acceptable to the patients and significantly improved QOL
7	Rao <i>et al.</i> , 2009 ^[84]	India	98 (45:45) II-III stage BC	60 min daily	Spielberger state-trait anxiety inventory and symptom checklist	Decrease in both self-reported state anxiety and trait anxiety
8	Vadiraja <i>et al.</i> , 2009 ^[85]	India	88 (44:44) Early stage BC	Yoga 60 min daily	Cortisol, mood, anxiety, depression, and stress	Yoga significantly decreased anxiety, depression, perceived stress, and cortisol
9	Vadiraja <i>et al.</i> , 2009 ^[86]	India	88 (44:44) II-III BC	Yoga 60 min daily	EORTCQOL C30 functional scales and PANAS. Assessments at baseline and after 6 weeks of radiotherapy treatment	Significant improvement in positive affect, cognitive function, and emotional function. Positive effect on role function, social function, and global QOL
10	Vadiraja <i>et al.</i> , 2009 ^[87]	India	88 (44:44) BCS	Yoga 60 min daily	EORTC QOL C30 symptoms	Decrease in psychological distress, fatigue, insomnia, and appetite loss
11	Barton <i>et al.</i> , 2010 ^[88]	UK	22 (11:11) Malignant lung disease	Breathing exercise, one session or three sessions	NRS of breathlessness severity; breathlessness distress; HADS questionnaire; coping (brief cope and NRS coping question); EQ-5D and EQ-VAS	Three sessions of training may improve breathlessness in these patients
12	Bränström <i>et al.</i> , 2010 ^[89]	Sweden	71 (32:39) 70 females and 1 male	8 weeks mindfulness training	Perceived stress and psychological wellbeing	A significant increase in psychological wellbeing

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Table 3: Contd...

Number	References	Country	Number of patients (intervention: control) Cancer type	Intervention	Measures	Results
13	Foley <i>et al.</i> , 2010 ^[90]	Australia	115 (distribution not available) Patients whose liver has been affected by cancer	2 h/week, 8 weeks Mindfulness-based cognitive therapy	Mindfulness, depression, anxiety, distress, QOL at baseline, 10 weeks later, and 3 months postintervention	A significant improvement on all the measures
14	Banasik <i>et al.</i> , 2011 ^[91]	USA	18 (9:9) BC	90 min/week, 8 weeks; Iyengar yoga	Cortisol, fatigue	Decrease in cortisol level and improvement in emotional wellbeing and fatigue
15	Garland <i>et al.</i> , 2011 ^[92]	Canada	110 (55:55) Cancer	Kabat-Zinn, MBSR	Insomnia, quality of sleep, stress, mood, mindfulness, and dysfunctional beliefs and attitude toward sleep at pretreatment, posttreatment, and at 3-month follow up	Intervention improved cancer-related psychological sequel
16	Kovačič and Kovačič, 2011 ^[93]	Slovenia	32 (16:16) BC	Relaxation training practiced at home for 3 weeks	Psychological distress and mental health	Patients receiving intervention had significantly less stress during hospitalization
17	Kovačič and Kovačič, 2011 ^[94]	Slovenia	32 (16:16) BC	Relaxation training practiced at home for 3 weeks	Rosenberg Self Esteem Scale	Statistically significant improvement
18	Kvillemo and Bränström, 2011 ^[95]	Sweden	18 (not specified) 17 women with BC and 1 man with lymphatic cancer	Kabat-Zinn Training involved body scan meditation, sitting and walking meditation, and hatha yoga	Stress-related complaints	Most participants expressed a number of perceived positive effects of participating in the mindfulness program including increased calm, enhanced sleep quality, more energy, less physical pain, and increased wellbeing. However, a few participants experienced no effect
19	Bränström <i>et al.</i> , 2012 ^[96]	Sweden	85 (39:46) Varying cancer diagnosis	8-week mindfulness training course	6-month follow-up effect of MBSR on perceived stress, depression, anxiety, posttraumatic stress symptoms, positive states of mind, coping self-efficacy, and mindfulness	Intervention increased mindfulness and decreased posttraumatic stress and avoidance
20	Bower <i>et al.</i> , 2012 ^[97]	USA	31 (16:15) BC	12 weeks Iyengar yoga	Primary: Fatigue, pretreatment, posttreatment, and 3-month after treatment Secondary: Change in vigor, depressive symptoms, sleep, perceived stress, and physical performance	Fatigue severity declined. Significant increase in vigor Positive change in depressive symptoms and perceived stress No significant change in sleep or physical performance

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Table 3: Contd...

Number	References	Country	Number of patients (intervention: control) Cancer type	Intervention	Measures	Results
21	Brotto <i>et al.</i> , 2012 ^[98]	Canada	31 (22:9) BC	90-min Mindfulness-cognitive behavior	Sexual functioning	Improvement in sexual functioning
22	Carmody <i>et al.</i> , 2012 ^[99]	USA	36 (17:19) Prostate	Dietary and MBSR	Ratio of animal to vegetable protein to evaluate whether a comprehensive dietary change was self-sustaining	A significant correlation between MBSR and animal to vegetable
23	Dhruva <i>et al.</i> , 2012 ^[100]	USA	23 (12:11) Cancer patients (not specified) receiving chemotherapy	<i>Pranayama</i> , during chemotherapy	Feasibility, cancer-related symptoms (fatigue, sleep disturbance, anxiety, depression, stress), and QOL	Intervention was feasible. <i>Pranayama</i> improved the sleep disturbance, anxiety, and QOL. The improvements were dose dependent
24	Hayama and Inoue, 2012 ^[101]	Japan	23 (11:12) Japanese women with gynecological cancer undergoing adjuvant chemotherapy	10 min deep breathing (abdominal, thoracic, arms raised)	Japanese version of profile of mood states-SF, and cancer fatigue scale	Intervention relieved tension-anxiety and fatigue
25	Hébert <i>et al.</i> , 2012 ^[102]	USA	54 (29:25) Men with rising PSA after prostate treatment	Diet, physical activity, and stress reduction	Tumor promotion and disease progression	Positive changes in lifestyle
26	Henderson <i>et al.</i> , 2012 ^[103]	USA	163 (53:52:58) MBSR, nutrition, usual care Early BC	8 weeks MBSR	QOL, coping (active behavioral and cognitive), spirituality, meaningfulness, depression, paranoid ideation, hostility, anxiety, unhappiness, and emotional control	A significant improvement in all the measures
27	Hoffman <i>et al.</i> , 2012 ^[104]	UK	229 (114:115) 0-III stage BC patients after surgery, chemotherapy and radiation	8 weeks MBSR Kabat-Zinn	Mood disturbance, anxiety, fatigue, confusion, and physical, emotional, and functional-wellbeing	Intervention improved mood, breast- and endocrine-related QOL, and wellbeing
28	Hoffman <i>et al.</i> , 2012 ^[105]	UK	92 A qualitative study in the group of patients who attended the intervention in the above study	8 weeks MBSR Kabat-Zinn	Calm, peace, confidence, awareness, coping, stress, anxiety, panic, judgmental, communication, personal relationship, and creating space	After MBSR, the patients reported more mindfulness and improvement in QOL and coping that can be used in different aspects of their lives Another important finding was that MBSR gave women time and space for themselves and permission to engage in self-care, thereby enhancing self-management
29	Lengacher <i>et al.</i> , 2012 ^[106]	USA	84 (41:43) BC	MBSR 6 weeks	Fatigue and QOL.	Reduction of fatigue and improvement in QOL

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Table 3: Contd...

Number	References	Country	Number of patients (intervention: control) Cancer type	Intervention	Measures	Results
30	Lerman <i>et al.</i> , 2012 ^[107]	USA	77 (53:24) Female with BC, ovarian cancer, endometrial cancer, colon cancer, Hodgkin's and non-Hodgkin's lymphoma, and choriocarcinoma	MBSR	SCL-90-R SOSI, and the EORTC QLQ-30	The treatment significantly improved the EORTC QLQ-30, some SOSI subscales and SCL-90-R
31	Littman <i>et al.</i> , 2012 ^[108]	USA	63 (32:31) Obese BC patients	5 practices/week, 6 months Vini yoga	QOL, fatigue and weight	QOL and fatigue improved significantly
32	Loudon <i>et al.</i> , 2012 ^[109]	Australia	40 (not specified) BC	8-week teacher-led yoga class with home-based daily yoga practice using DVD	Effect on lymphedema and associated symptoms QOL, range of motion of the arm and thoracic spine, shoulder strength, and physical activity	Improvement in the measures
33	Monti <i>et al.</i> , 2012 ^[110]	USA	18 (8:10) BC	MBAR - art + meditation Kabat-Zinn	Cerebral blood flow, stress, and anxiety	A significant increase in cerebral blood flow and decrease in anxiety
34	van der Lee and Garssen, 2012 ^[111]	The Netherlands	100 (72:28) All cancer types	Mindfulness cognitive	Fatigue	The intervention was effective in reducing the cancer-related fatigue

BC=Breast cancer, CS=Cancer survivors, MBSR=Mindfulness-based stress reduction, QOL=Quality of life, PSA=Prostate specific antigen, FACT-B=Functional assessment cancer therapy-breast, FACIT-SP=Functional assessment of chronic illness therapy-spiritual wellbeing, SDF=Short-form, EORTCQOL=European Organization for Research in the Treatment of Cancer-Quality of Life, PANAS=Positive and negative affect schedule, NRS=Numerical rating scales, HADS=Hospital Anxiety and Depression Scale, VAS=Visual Analog Scale, SCL=Symptoms checklist, SOSI=Symptoms of Stress Inventory, DVD=Digital Versatile Disc

Table 4: Summary of randomized controlled trials of yoga in cancer from 2013 to 2016

Number	Reference	Country	Number of patients (intervention: control) Cancer type	Intervention	Measures	Results
1	Andersen <i>et al.</i> , 2013 ^[112]	Denmark	336 (168:168) BC	MBSR, gentle meditation, yoga	Sleep quality	MBSR had a statistically significant effect on sleep quality just after the intervention but no long-term effect
2	Bränström <i>et al.</i> , 2013 ^[113]	Sweden	71 (32:39) Cancer diagnosis	MBSR, Kabat-Zinn	Cortisol levels and psychological outcomes	No effect on cortisol levels at 3-month or 6-month follow-up A significant effect on awakening cortisol No association between changes in psychological outcomes and cortisol levels
3	Cadmus-Bertram <i>et al.</i> , 2013 ^[114]	USA	32 (16:16) BC	5 times/week, for 6 months of Vini yoga,	Adherence	High levels of facility- and home-based yoga practice were achieved

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Number	Reference	Country	Number of patients (intervention: control) Cancer type	Intervention	Measures	Results
4	Carlson <i>et al.</i> , 2013 ^[115]	USA	271 (113:104:54) BC, distress	including at least 1 weekly facility-based session MBCR/SET/SMS	Primary: Mood and diurnal salivary cortisol. Secondary: stress symptoms, QOL, and social support	The intervention was superior for improving stress levels, QOL, and social support. The intervention also resulted in more normative diurnal cortisol profiles
5	Henderson <i>et al.</i> , 2013 ^[116]	USA	163 (53:52:58) BC	8-week MBSR plus 3 additional sessions	Primary: BC-specific QOL and psychosocial coping. Secondary: Meaningfulness, helplessness, cognitive avoidance, depression, paranoid ideation, hostility, anxiety, global severity, anxious preoccupation, and emotional control	Improvement in all the measures
6	Kenne Sarenmalm <i>et al.</i> , 2013 ^[117]	Sweden	150 (50:50:50) BC	Meditation, yoga, mind-body exercise 8 weeks (follow up 3, 6, 12 months and 5 years)	QOL and immune response	Both improved
7	Kim <i>et al.</i> , 2013 ^[118]	Republic of Korea	102 (51:51) BC	Meditation therapy 6 weeks/12 sessions	Anxiety, depression, fatigue and QOL	Improvement in fatigue, anxiety, QOL and emotional faculties
8	Kovačič <i>et al.</i> , 2013 ^[119]	Slovenia	32 (16:16) BC	Methods specified Yoga in daily life Program well defined 3 weeks, 1 h daily	Psychological parameters, anxiety Immediate and long-term affect	Improvement in anxiety
9	Kumar <i>et al.</i> , 2013 ^[120]	India	147 (78:69)	20 min daily for 3 months, <i>Sudarshan kriya</i> , <i>Bhastrika pranayama</i> , and <i>pranayama</i>	Serum cortisol, pain, and liver and kidney function	Reduction in cortisol level at 3 and 6 months visit
10	Lengacher <i>et al.</i> , 2013 ^[121]	USA	82 (40:42) BC	MBSR, Kabat-Zinn's 6 weekly, 2 h	Immune recovery: lymphocyte subsets, T-cell activation, and production of T-helper cells	Intervention promoted a more rapid recovery of functional T-cells

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Number	Reference	Country	Number of patients (intervention: control) Cancer type	Intervention	Measures	Results
11	Lipschitz <i>et al.</i> , 2013 ^[122]	USA	57 (20:19:18) (mindful meditation/ mind-body bridging/ sleep hygiene education) CS	Mindful meditation, mind-body bridging, sleep hygiene education 3 weeks, 3 sessions a week	Alpha-amylase, cortisol	Positive influence on sympathetic activity
12	Malboeuf-Hurtubise <i>et al.</i> , 2013 ^[123]	Canada	40 (20:20) Teenagers with cancer	MBSR 8 weekly sessions, 90 min Program well defined	QOL, sleep, mood	Improved
13	Milbury <i>et al.</i> , 2013 ^[124]	USA	42 (18:24) BC postchemo, cognitive impairment	6 weeks, 2 weekly sessions Tibetan sound meditation	QOL, depressive symptoms, sleep disturbance, fatigue, and spirituality	Short-term improvement in cognitive function, mental health and spirituality
14	Morano <i>et al.</i> , 2013 ^[125]	Brazil	24 (12:12) Lung cancer	Breathing exercise 4 weeks, 5 sessions per week	Preoperative functional capacity, postoperative respiratory morbidity	Improvement in preoperative functional capacity and decrease in the postoperative respiratory morbidity
15	Mustian <i>et al.</i> , 2013 ^[126]	USA	410 (206:204) BCS sleep disruption	YOCAS* hatha yoga, <i>pranayama</i> , meditation 4 weeks, 2 weekly sessions, 75 min	Sleep quality	Sleep quality improved and sleep medication reduced
16	Siedentopf <i>et al.</i> , 2013 ^[127]	Germany	93 (49:44) Early BC patients	75 min twice a week, for 5 weeks Yoga <i>asanas</i> and breathing exercise	Physical activity and QOL	Improvement in QOL and functional status
17	Spahn <i>et al.</i> , 2013 ^[128]	Germany	64 (32:32) BC	Multimodal mind-body program 10 weeks	Fatigue, QOL, functional wellbeing, anxiety, and depression	Programs improved QOL and fatigue
18	Würtzen <i>et al.</i> , 2013 ^[129]	Denmark	336 (168:168) I-III stage BC	MBSR yoga, clinical psychology consultation	Anxiety and depression	Significantly long-term decrease in symptoms
19	Andysz <i>et al.</i> , 2014 ^[130]	Poland	28 (12:16) BCS	90 min weekly for 10 weeks, Iyengar yoga with <i>asanas</i> , <i>pranayama</i> and relaxation	QOL	Significant improvement in QOL
20	Bower <i>et al.</i> , 2014 ^[131]	USA	31 (16:15) BC fatigue	Iyengar yoga restorative practice 12 weeks	Inflammatory markers and salivary cortisol	Reduced inflammatory parameters and induced anti-inflammatory parameters
21	Carlson <i>et al.</i> , 2014 ^[132]	Canada	184 (74:73:37) (mindfulness-based cancer recovery/	Mind-body therapies tailored to individual needs	Mood, stress symptoms, QOL, spiritual wellbeing,	Improvement in stress symptoms and QOL

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Number	Reference	Country	Number of patients (intervention: control) Cancer type	Intervention	Measures	Results
22	Chandwani <i>et al.</i> , 2014 ^[133]	USA	supportive-expressive therapy/stress management seminar) Stage I-III BC 163 (53:56:54) (yoga: Stretching: Waitlist groups)	Integrated yoga program 3 times/ week, for 6 weeks	posttraumatic growth, social support, and salivary cortisol Fatigue, depression, sleep quality, and salivary cortisol	Yoga improved QOL and physiological changes associated with radiation therapy
23	Garland <i>et al.</i> , 2014 ^[134]	Canada	111 (64:47) Cancer with insomnia	MBSR/cognitive behavioral therapy	Insomnia severity, sleep quality, sleep beliefs, mood, and stress	Significant change in sleep and psychological outcomes
24	Kiecolt-Glaser <i>et al.</i> , 2014 ^[135]	USA	200 (100:100) BCS	Hatha Yoga 12 weeks, 90-min twice per week	Inflammation, mood, and fatigue	Yoga reduced fatigue and inflammation
25	Lengacher <i>et al.</i> , 2014 ^[136]	USA	142 (74:68) BC	MBSR Kabat-Zinn's adapted for BC 6 weeks	Telomerase activity telomerase length	Telomerase activity increased steadily, telomerase length did not change
26	Lengacher <i>et al.</i> , 2014 ^[137]	USA	82 (40:42) BC	MBSR 6 weeks	Fear of recurrence, stress anxiety, and physical functioning	Reduced fear of recurrence and improved physical functioning which reduces perceived stress and anxiety
27	Louden <i>et al.</i> , 2014 ^[138]	Australia	28 (15:13) BC lymphedema	8 weekly 90 min sessions 40 min a day DVD	Volume of lymphedema, tissue induration, levels of sensations, pain, fatigue, and QOL	Decrease in tissue induration, improved QOL, but on week 12, arm volume increased
28	Reich <i>et al.</i> , 2014 ^[139]	USA	41 (17:24) BC	MBSR Kabat-Zinn Hatha yoga meditation 6 weekly 2 h sessions and 15-45 min daily independently	B-lymphocytes and interferon- γ +CD4+CD8, IL-4	Biomarkers were significantly positively related to symptom improvement
29	Taso <i>et al.</i> , 2014 ^[140]	Taiwan	60 (30:30) Nonmetastatic BC	Yoga program tailored for BC 8 weeks, twice a week for 60 min	Depression, anxiety, and fatigue	Yoga exercise significantly reduced overall fatigue but not depression
30	Zernicke <i>et al.</i> , 2014 ^[141]	USA	62 (30:32) Distressed CS	MBCR (mindfulness-based cancer recovery)	Mood, stress, spirituality, awareness	Reduction of mood disturbance and stress symptoms, as well as an increase in spirituality and mindfully acting with awareness
31	Bower <i>et al.</i> , 2015 ^[142]	USA	71 (39:32) Early stage BC	Kabat-Zinn meditation MAPs 6 weeks	Stress, depression, and inflammatory activity	Significant reductions in stress, pro-inflammatory gene expression and

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Number	Reference	Country	Number of patients (intervention: control) Cancer type	Intervention	Measures	Results
						inflammatory signaling Marginal reductions in depressive symptoms Reductions in fatigue, sleep disturbance, and vasomotor symptoms and increase in peace and meaning and positive effect on psychological and behavioral measures but not maintained at the 3-month follow-up assessment, although reductions in cancer-related distress were observed at that assessment
32	Carlson <i>et al.</i> , 2015 ^[143]	Canada	88 (34:36:18) MBCR/ supportive-expressive Group therapy/stress management seminar Stage I-III distressed (BC)	MBCR gentle hatha yoga and meditation	Telomere length, mood, and stress	Between the MBCR and SET groups, there were no differences in telomere/single-copy gene ratio, but a trend effect was observed between the combined intervention group and controls; telomere length in the intervention group was maintained, whereas it was found to decrease for control participants. There were no associations noted between changes in telomere length and changes in mood or stress scores over time
33	Chakrabarty <i>et al.</i> , 2015 ^[144]	India	160 (80:80) BC patients who received radiation therapy	20 min twice a day, 5 days a week, for 6 weeks, <i>pranayama</i>	Fatigue	Fatigue reduced in the intervention group
34	Cramer <i>et al.</i> , 2015 ^[145]	Germany	40 (19:21) BC with menopausal symptoms	90 min/week for 10 weeks, traditional Hatha yoga and meditation	Primary: total menopausal symptoms Secondary: QOL, fatigue, depression and anxiety. Assessments were done at week 12 and week 24 after randomization	Yoga significantly lowered total menopausal symptoms at week 12 and 24 At week 12, the yoga group reported less soma to vegetative, psychological, and urogenital menopausal symptoms; less fatigue; and improved QOL

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Number	Reference	Country	Number of patients (intervention: control) Cancer type	Intervention	Measures	Results
35	Derry <i>et al.</i> , 2015 ^[146]	USA	186 (96:90) BC	Hatha yoga	Cognitive complaints	At week 24, all effects persisted except for psychological menopausal symptoms Yoga effectively reduced survivors' cognitive complaints
36	Dowd <i>et al.</i> , 2015 ^[147]	USA	124 (62:62) Cancer unrelated pain	MIA Pain computerized intervention	Pain Interference, pain intensity and disability, pain acceptance, psychological distress, mindfulness, life satisfaction, impression of change	Increase in subjective wellbeing, reduction in pain and long-term effect on increases in their ability to manage emotions, manage stress, and enjoy pleasant events
37	Garland <i>et al.</i> , 2015 ^[148]	Canada	57 (no distribution) CS, BC/solid tumors/ hematological tumors	MM/MBB/SH	Salivary cortisol levels, mindfulness, wellbeing	CS who reported lower baseline levels of dispositional mindfulness exhibited increases in waking cortisol over time, whereas those who reported higher baseline dispositional mindfulness showed comparatively stable waking cortisol over the study period. Furthermore, increases in waking cortisol were associated with decreased wellbeing over the study period
38	Garland <i>et al.</i> , 2015 ^[149]	Canada	72 (32:40) Cancer	MBCR/CBT	Mindfulness, dysfunctional sleep, and insomnia at baseline, post-program, and 3-month follow-up	Both CBT-I and MBCR reduced insomnia severity and dysfunctional sleep beliefs and improved awareness
39	Grossman <i>et al.</i> , 2015 ^[150]	Switzerland	62 (33:29) HSCT	MBI-version of MBSR, dynamic yoga	Primary: QOL Secondary: depression, fatigue, anxiety, and personal goal attainment	Improved QOL, reduced depression and anxiety at post intervention At 3-month follow-up, benefits were modest
40	Hughes <i>et al.</i> , 2015 ^[151]	USA	94 (31:31) BC	Yoga based exercise program developed for this study (breath awareness, <i>ranayama</i> , <i>Surya Namaskar</i> , etc.)	Physical fitness, strength, flexibility, cardiovascular functions	Yoga improved physical fitness

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Number	Reference	Country	Number of patients (intervention: control) Cancer type	Intervention	Measures	Results
41	Johns <i>et al.</i> , 2015 ^[152]	USA	35 (18:17) CS	7 weeks MBSR intervention	Primary: fatigue Secondary: fatigue severity, vitality, disability, depression, anxiety, and sleep disturbance Assessed at baseline, postintervention, and 1-month follow-up	MBSR reduced fatigue, fatigue severity, depression, and sleep disturbance. Results were maintained or strengthened at 1-month follow-up, the point at which significant improvements in disability and anxiety occurred. Improvements in all outcomes were maintained 6 months after completing the course
42	Johnson <i>et al.</i> , 2015 ^[153]	UK	156 (52:104) Malignant lung disease	Four breathing technics: Breathing control, walking breath control, relaxation, Anxiety management (3 h-long sessions at weekly intervals, or during a single hour-long session)	Compared 1 and 3, 1 h breathing sessions	There was no difference in 1 and 3 sessions
43	Lengacher <i>et al.</i> , 2015 ^[154]	USA	79 (38:41) BC	6-week MBSR	Sleep parameters	Small nonsignificant improvements in subjective sleep parameters
44	Lengacher <i>et al.</i> , 2015 ^[155]	USA	72 (37:35) BC who completed chemo	MBSR Kabat-Zinn adapted for BC	Association of SNP with cognitive impairment, at baseline, and at 6 and 12 weeks	SNPs in four genes were found associated with cognitive impairment
45	Lipschitz <i>et al.</i> , 2015 ^[156]	USA	30 (21 female: 9 male) (11:10:9) CS experiencing high levels of distress	MM/MBB/SHE	sOT related to sleep quality	Improvement in sleep disturbance
46	Long Parma <i>et al.</i> , 2015 ^[157]	USA	94 (31:31:32) Yoga focus: control: comparison group	1-hr thrice per week for 6 months Hatha yoga	Inflammatory markers (IL-6, IL-8, CRP), body composition, and cardiorespiratory capacity	A significant decrease in body adipose tissue
47	McCall <i>et al.</i> , 2015 ^[158]	UK	12 (4:4:4) Low-, medium-, and high-dose yoga in adult cancer patients	Low dose - 15 yoga instruction, 30 min <i>pranayama</i> and <i>Satsang</i> Medium dose - 15 min instruction,	QOL, physical, psychological, spiritual, and social wellbeing	Significant improvement in physical wellbeing in groups of low- and medium-dose yoga

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Table 4: Contd...

Number	Reference	Country	Number of patients (intervention: control) Cancer type	Intervention	Measures	Results
				30 min <i>asanas</i> , 120 min <i>pranayama</i> , <i>asanas</i> , and <i>dhyana</i>		Significant improvement in psychological, spiritual, and social wellbeing in groups of low- and high-dose yoga
48	Peppone <i>et al.</i> , 2015 ^[159]	USA	167 (84:83) BC	High dose - 15 min instructions, 30 min <i>pranayama</i> , 30 min <i>asanas</i> training, 60 min <i>pranayama</i> , <i>asanas</i> and <i>dhyana</i> YOCAS	Musculoskeletal symptoms among BC survivors receiving hormone therapy (AI or TAM) FSS and QOL	Intervention significantly reduced general pain, muscle aches, and physical discomfort
49	Rahmani <i>et al.</i> , 2015 ^[160]	Iran	24 (12:12)	2-h weekly for 8 weeks Hatha yoga		Significant difference in QOL, emotion, social and cognitive dimensions, future perspective, and FSS
50	Rao <i>et al.</i> , 2015 ^[161]	India	98 (45:53) BC patient undergoing conventional therapy	1-h daily for 24 weeks, <i>Pranayama</i> , <i>asanas</i> , breathing exercise, meditation, and relaxation techniques	BDI	A significant improvement in depression score, symptom severity, and distress
51	Sprod <i>et al.</i> , 2015 ^[162]	USA	97 (53:44) CS over 60 years	YOCAS (YOCAS®)	Cancer-related fatigue (general, physical, emotional, and mental) and global side effect burden in older CS	YOCAS was an effective yoga intervention for reducing cancer-related fatigue, physical fatigue, mental fatigue, and global side-effect burden among older CS
52	Würtzen <i>et al.</i> , 2015 ^[163]	Denmark	336 (168:168) Stage I-III BC	MBSR yoga and psychological education	Somatic symptoms, distress, mindfulness skills and spiritual wellbeing, post-intervention and after 6 and 12 months	MBSR affected somatic symptom burden related to BC after 6 but not 12 months follow-up
53	Vardar Yağlı <i>et al.</i> , 2015 ^[164]	Turkey	52 (24:28) BC	Yoga (<i>asanas</i> , <i>pranayama</i> , meditation). 30 min/day, 3 day/ week for 6 weeks	Functional capacity, Peripheral muscle strength, fatigue severity level, QOL	Significant increases in functional capacity, peripheral muscle strength, QOL, and fatigue

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Number	Reference	Country	Number of patients (intervention: control) Cancer type	Intervention	Measures	Results
54	Yagli and Ulger, 2015 ^[165]	Turkey	20 (10:10) BC	Classical yoga program	Pain, fatigue and sleep quality	Yoga diminished pain, fatigue and improved sleep quality
55	Cramer <i>et al.</i> , 2016 ^[166]	Germany	54 (27:27) Nonmetastatic colorectal cancer	90 min/week for 10 weeks, traditional Hatha yoga	Primary: disease-specific QOL Secondary: Spiritual wellbeing; fatigue; sleep disturbances; depression and anxiety	No effects of yoga on health-related QOL (due to a high attrition rate and low intervention adherence, definite conclusions could not be drawn)
56	Lötzke <i>et al.</i> , 2016 ^[167]	Germany	92 (45:47) Stage I-III BC patients	60-min session of for 12 weeks plus 40 min per week of Iyengar-Yoga	Health-related QOL, mindfulness, spirituality, life satisfaction, and cancer-related fatigue	There was no significant difference between the intervention group and control group
57	Pagliari <i>et al.</i> , 2016 ^[168]	Italy	103 (52:51) Mostly BC, 95 females and 7 males	Tong Len meditation	Stress, anxiety, depression, fatigue, and self-perceived QOL in cancer patients	The research highlighted some psychological improvements through Tong Len distant meditation in a group of patients unknown to meditators
58	Rabin <i>et al.</i> , 2016 ^[169]	USA	35 (19:16) Adult CS (age 18-39)	Physical exercise plus meditation - "relaxation and exercise for wellness"	Feasibility and acceptability	It proved feasibility and acceptability and may increase physical activity, improve fitness, and enhance mood

BC=Breast cancer, CS=Cancer survivors, MBSR=Mindfulness-based stress reduction, QOL=Quality of life, HSCT=Hematopoietic stem cell transplantation, MBCR=Mindfulness-based cancer recovery, CBT=Cognitive behavior therapy, CBT-I=CBT for insomnia, SET=Supportive-expressive group therapy, SMS=Stress management seminar, MAPs=Mindfulness awareness practices, MIA=Mindfulness in action, MM=Mindfulness meditation, MBB=Mind body bridging, SH=Sleep hygiene, YOCAS=Yoga for cancer survivors, IL=Interleukin, SNP=Single nucleotide polymorphism, sOT=Salivary oxytocin, CRP=C-reactive protein, AI=Aromatase inhibitors, TAM=Tamoxifen, FSS=Fatigue severity scale, MBI=Mindfulness-based intervention

Australia (*n* = 4), three each from Denmark, Japan, Slovenia, South Korea, and Turkey, two from the Netherlands, and one each from Brazil, Italy, Iran, Poland, Singapore, Switzerland, and Taiwan.

Discussion

This article presents a systematic review of the efficacy of yoga interventions as adjuvants to conventional cancer care; i.e., cancer and cancer treatment-related symptoms and side effects.

The diagnosis of cancer and its treatment-related toxicity causes a high degree of emotional distress in patients and their families, consequently leading to a number of negative implications.^[81,104,116,170-172] Family members of cancer patients, the parents of children with cancer in particular,

and the spouses of cancer survivors experience increased anxiety, depression, and feeling of helplessness.^[173-176] Furthermore, pharmacological interventions used to alleviate the adverse symptoms are also associated with side effects, toxicity, and addictions, posing a great challenge for the cancer care providers. Therefore, the patients tend to use nonpharmacological therapies.

The literature review presented here shows that the yoga interventions are beneficial in improving the adverse symptoms in cancer patients – caused either by the disease or its treatment. Due to the immensity of its beneficial effects, the integrations of yoga in cancer care are gradually increasing,^[177] and a number of major cancer centers are adding integrative oncology in their programs. The prevalence, demographics, and trend of the use of yoga

Table 5: Cancer and its treatment-related adverse symptoms

Categories	Symptoms
Psychological	Anxiety, anger, depression, stress, PTSD, poor self-esteem
Physical and physiological	Anemia, appetite loss, balance, bleeding and bruising (thrombocytopenia) constipation, diarrhea, edema, fatigue, hair loss, hypertension, impaired immunity, infection and neutropenia, insomnia, lymphedema, mouth and throat problems, nausea and vomiting, nerve problems (peripheral neuropathy), pain, rashes, respiratory problems, sexual and fertility problems (men and women), skin and nail changes, and urinary and bladder problems
Emotional	Fear of recurrence, delirium, memory and concentration problems, and social adjustment
General	Overall QOL

QOL=Quality of life, PTSD=Posttraumatic stress disorder

practices in various disease conditions have been reviewed by Field.^[29]

The salient features of yoga as therapeutic tool are that it is simple and easy to administer; it could be administered at any time, at any place, and by any person, irrespective of age or gender; is cost-effective; and could be administered to one person or to a group in the clinical settings or at home. The patients are involved in their own therapy. In contrast to pharmacological interventions, it is nontoxic, nonpervasive and therefore could be used during pregnancy and lactation. It may be used by patients, medical professionals, and caregivers for their own benefit and for others. An important point to note is that yoga also enriches the spiritual needs of patients that are not met by conventional therapy (surgery, radiation, and chemotherapy). It could be used as an adjuvant with other treatments.

The greatest challenges for cancer care providers are (1) how to prevent onset of cancer (transformation of a cell into a cancer cell), (2) how to arrest its progression, (3) how to cure cancer, and (4) how to maintain the survivors' QOL. Could the integration of yoga in conventional therapy meet these challenges?

The studies reviewed here provide ample evidence of the beneficial effects of yoga on the psychological, physical, and emotional health and QOL of cancer patients. While direct studies of the effect of yoga on the prevention, progression, and cure of cancer are almost lacking, following indirect observations suggest that yoga may meet the above-listed challenges.

Among other factors, it is well known that the body's immune system plays an important role in the development of cancer. During normal cell division, some cells acquire mutations. Aided by the risk factors (tobacco smoke, chemicals, viral infections, etc.), the mutated cell may acquire additional mutations and continues to proliferate and develops into cancer. Normally, an efficient immune system destroys the mutated cell as soon as it is formed; however, if the immune system is impaired or weakened, the mutated cell escapes destruction and continues to pathological proliferation. A number of studies have shown that the sustained stress (commonly observed in cancer patients) negatively affects the cellular immunity.^[178-180] An impaired immune system may facilitate tumor development.^[178,181-185] Several studies have shown

that yoga reduces stress, depression, and anxiety, changes cellular milieu by genomic alteration, and enhances cellular immunity.^[186,187] It is therefore very likely that yoga could prevent tumorigenesis and progression and possibly help cure cancer. Interestingly, a number of case reports from Meares demonstrated that the practice of yoga/meditation was able to regress the growth of tumors.^[188-191] The above findings suggest that yoga may help prevent tumorigenesis and progression and ultimately cure cancer. Of course, well-designed studies are needed to examine this hypothesis.

This review revealed a number of gaps in the reported studies. As stated in our earlier review,^[192] one of the most significant methodological problems was the heterogeneity of yoga techniques and the assessment of protocols used in different studies [Tables 1-4], thus lacking a standardized approach. Other deficiencies were uncertainty of an effective dose; lack of studies on side effects/risks; small sample sizes; lack of follow-up studies; most of the outcomes were self-reported; lack of recruitment methods and randomized process, cointerventions, and compliance. Furthermore, except for breast cancer, studies on other cancer types remain limited. Other limitations noted were that, in spite of increasing interest in integrating holistic approaches in cancer care, the awareness in public, medical professionals, and caregivers remains limited. It should be noted that, unlike objective pharmacological interventions, yoga is a subjective intervention, and therefore, the same metrics may not be applicable to compare the two approaches, and the problems will persist with this kind of intervention.^[29,192] However, more well-designed randomized control trials using larger sample sizes, longer duration, follow-up studies, well-specified outcome measures, and different cancer types are necessary to establish benefits of yoga in the management of cancer.^[192]

Greater efforts must be made to integrate yoga as a mainstream therapeutic program. This includes scientific mindset and acceptability of yoga as an important therapeutic tool. It is therefore necessary to introduce courses on yoga therapy in medical schools, seek accreditation by authentic agencies, provide insurance coverage for yoga therapies, and educate the public about the benefits of yoga so that it is integrated in the current cancer therapeutic programs. It is also recommended that cancer caregivers are trained and certified as the "yoga

therapists” who have knowledge of the particular disease and understand the needs of the patients.

Conclusion

This article reviews the evidence-based research on the effects of yoga in cancer care when integrated as an adjuvant with conventional therapy. Despite a wide range of methodological gaps and limitations, yoga interventions were shown to be beneficial and yielded positive results without any adverse outcomes. While work must continue using well-designed clinical trials, the findings reported here strongly support the integration of yoga in the conventional cancer care.

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Conflicts of interest

There are no conflicts of interest.

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