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, 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,
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.[21] 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.[32] 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),

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

| Number | Reference | Country | Number of patients | Cancer type | Interventions | Measures | Results |
|--------|-----------|---------|-------------------|-------------|--------------|----------|---------|
| 1      | Saxe et al., 2001[32] | USA     | 10                | Prostate cancer | 10 week Diet and MBSR | PSA | Decreases the rate of PSA increase |
| 2      | Carlson et al., 2004[33] | Canada  | 59/10 BC/prostate cancer | MBSR 8-week, 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 et al., 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 et al., 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 |

Contd...
| Number | Reference | Country | Number of patients | Cancer type | Interventions | Measures | Results |
|--------|-----------|---------|--------------------|-------------|---------------|----------|---------|
| 6      | Bauer-Wu et al., 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 et al., 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 et al., 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 et al., 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 et al., 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 (asanas, pranayama, 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 et al., 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 et al., 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 et al., 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 |

*Contd...*
| Number | Reference | Country | Cancer type | Interventions | Measures | Results |
|--------|-----------|---------|-------------|---------------|----------|---------|
| 16     | Fouladbakhsh et al., 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 et al., 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 et al., 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 et al., 2013[50] | USA     | 18 BC | 8-week yoga intervention | Health promoting symptoms (physical, social, and mental health) | Improvement in all measures |
| 20     | Ross Zahavich et al., 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 et al., 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 et al., 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 et al., 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 et al., 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 et al., 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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Table 1: Contd...

| Number | Reference            | Country   | Number of patients | Cancer type                                                                 | Interventions                                                                 | Measures                                                                    | Results                                                                 |
|--------|----------------------|-----------|--------------------|-----------------------------------------------------------------------------|-------------------------------------------------------------------------------|----------------------------------------------------------------------------|--------------------------------------------------------------------------|
| 26     | Wurz et al., 2014[57]| Canada    | 8 pediatric cancer patients, (4 male, 4 female) | Follow-up at 3 and 6 months poststudy 12-week yoga intervention, 2 times/week | HRQL, physical fitness, and physical fitness outcome level (PAL)              | Significant improvement in functional mobility, Hamstring mobility, and total PAL | 10 of 11 patients completed the study, thus proving the feasibility Yoga reduced fatigue |
| 27     | Diorio et al., 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 Savasana (corpus pose) | Feasibility, QOL                                                                 |                                                                                                                                     |
| 28     | Hooke et al., 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=Nonsmall 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 et al., 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      | Speca et al., 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 et al., 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 et al., 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 et al., 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 et al., 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 et al., 2004[67] | USA           | 38 (19:19) Lymphoma | Tibetan yoga | Feasibility and sleep quality | The program was feasible and improved sleep-related outcomes |
| 9      | Hiderley 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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| 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 et al., 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 et al., 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 et al., 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 et al., 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 et al., 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 et al., 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 et al., 2008[77]      | India        | 98 (45:53) Patient diagnosed with operable BC | An “integrated yoga program” (pranayama, 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, HADSs=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, 1R-PEP=Inspiratory resistance-positive expiratory pressure, HSCT=Hematopoietic stem cell transplant, MBAT=Mindfulness-based art therapy, MANE=Morrow Assessment of Nausea and Emesis, NSCLC=Nonsmall 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) | Intervention | Measures | Results |
|-------|------------|---------|------------------------------------------|--------------|----------|---------|
| 1     | Carson et al., 2009[78] | USA | 37 (17:20) BC, IA-IIIB | 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 et al., 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 et al., 2009[80] | USA | 24 (12:12) Obese BC patients | Spiritual counseling and meditation | Spiritual wellbeing and dietary quality | Both were positively affected |
| 4     | Lengacher et al., 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 et al., 2009[82] | USA | 130 (64:66) II-IV stage BC | Transcendental meditation | FACT-B, FACT-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 et al., 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 et al., 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 et al., 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 et al., 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 et al., 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 et al., 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 et al., 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 |

Contd...
| Number | References | Country          | Number of patients (intervention: control) | Cancer type | Intervention | Measures                                                                 | Results                                           |
|--------|------------|------------------|-------------------------------------------|-------------|--------------|--------------------------------------------------------------------------|---------------------------------------------------|
| 13     | Foley et al., 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 et al., 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 et al., 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 significantly 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 et al., 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 et al., 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 |

Contd...
| Number | References | Country      | Number of patients (intervention: control) | Intervention | Measures                                      | Results                                                        |
|--------|------------|--------------|--------------------------------------------|--------------|-----------------------------------------------|----------------------------------------------------------------|
| 21     | Brotto et al., 2012[98] | Canada       | 31 (22:9) BC                               | 90-min Mindfulness-cognitive behavior | Sexual functioning | Improvement in sexual functioning               |
| 22     | Carmody et al., 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 et al., 2012[100] | USA          | 23 (12:11) Cancer patients (not specified) receiving chemotherapy | Pranayama, during chemotherapy | Feasibility, cancer-related symptoms (fatigue, sleep disturbance, anxiety, depression, stress), and QOL | Intervention was feasible. Pranayama 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 et al., 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 et al., 2012[103] | USA          | 163 (53:52:58) MBSR, nutrition, usual care Early BC | 8 weeks MBSR Kabat-Zinn | 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 et al., 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 et al., 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 et al., 2012[106] | USA          | 84 (41:43) BC MBSR 6 weeks | Fatigue and QOL. | Fatigue and QOL. | Reduction of fatigue and improvement in QOL |
Table 3: Contd...

| Number | Reference | Country       | Number of patients (intervention: control) | Intervention | Measures                                      | Results                                                                 |
|--------|-----------|---------------|--------------------------------------------|--------------|-----------------------------------------------|------------------------------------------------------------------------|
| 30     | Lerman et al., 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 et al., 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 et al., 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 et al., 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 et al., 2013[112] | Denmark         | 336 (168:168) BC                            | 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      | Brännström et al., 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 et al., 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 | Contd... |

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### Table 4: Contd...

| Number | Reference | Country        | Number of patients (intervention: control) | Cancer type | Intervention Measures | Results                                                                 |
|--------|-----------|----------------|--------------------------------------------|-------------|-----------------------|------------------------------------------------------------------------|
| 4      | Carlson et al., 2013[113] | USA         | 271 (113:104:54) BC, distress                |             | 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 et al., 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 et al., 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 et al., 2013[118] | Republic of Korea | 102 (51:51) BC                              |             | Meditation therapy 6 weeks/12 sessions Methods specified | Anxiety, depression, fatigue and QOL. Improvement in fatigue, anxiety, QOL and emotional faculties. |
| 8      | Kovačič et al., 2013[119] | Slovenia | 32 (16:16) BC                               |             | 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 et al., 2013[120] | India     | 147 (78:69) BC                              |             | 20 min daily for 3 months, Sadarshan kriya, Bhashrika pranayama, and pranayama | Serum cortisol, pain, and liver and kidney function Reduction in cortisol level at 3 and 6 months visit. |
| 10     | Lengacher et al., 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. |
| Number | Reference | Country     | Number of patients (intervention: control) Cancer type | Intervention | Measures | Results                                      |
|-------|-----------|-------------|-----------------------------------------------------|--------------|---------|---------------------------------------------|
| 11    | Lipschitz et al., 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 et al., 2013[123] | Canada      | 40 (20:20) Teenagers with cancer | MBSR 8 weekly sessions, 90 min Program well defined | QOL, sleep, mood | Improved                                     |
| 13    | Milbury et al., 2013[124] | USA         | 42 (18:24) BC postchemo, cognitive impairment | Tibetan sound meditation 6 weeks, 2 weekly sessions | QOL, depressive symptoms, sleep disturbance, fatigue, and spirituality | Short-term improvement in cognitive function, mental health and spirituality |
| 14    | Morano et al., 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 et al., 2013[126] | USA         | 410 (206:204) BCS sleep disruption | YOCAS* hatha yoga, pranayama, meditation 4 weeks, 2 weekly sessions, 75 min | Sleep quality | Sleep quality improved and sleep medication reduced |
| 16    | Siedentopf et al., 2013[127] | Germany     | 93 (49:44) Early BC patients | Yoga *asanas* and breathing exercise 75 min twice a week, for 5 weeks | Physical activity and QOL | Improvement in QOL and functional status |
| 17    | Spahn et al., 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 et al., 2013[129] | Denmark     | 336 (168:168:168) I-III stage BC | MBSR yoga, clinical psychology consultation | Anxiety and depression | Significantly long-term decrease in symptoms |
| 19    | Andysz et al., 2014[130] | Poland      | 28 (12:16) BCS | 90 min weekly for 10 weeks, *Iyengar yoga with asanas, pranayama* and relaxation | QOL | Significant improvement in QOL |
| 20    | Bower et al., 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 et al., 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 |

*Contd...*
| Number | Reference | Country | Number of patients (intervention: control) | Cancer type | Intervention | Measures | Results |
|--------|-----------|---------|-------------------------------------------|-------------|-------------|----------|---------|
| 22     | Chandwani et al., 2014[133] | USA     | 163 (53:56:54) Stage I-III BC (yoga: Stretching: Waitlist groups) | Stage 0-III, BC undergoing radiotherapy | Integrated yoga program 3 times/week, for 6 weeks | posttraumatic growth, social support, and salivary cortisol | Yoga improved QOL and physiological changes associated with radiation therapy |
| 23     | Garland et al., 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 et al., 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 et al., 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 et al., 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 et al., 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 et al., 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 et al., 2014[140] | Taiwan  | 60 (30:30) Nonmetastatic BC | | Yoga program tailored for BC 8 weeks, twice a week for 60 min independently | Depression, anxiety, and fatigue | Yoga exercise significantly reduced overall fatigue but not depression |
| 30     | Zernicke et al., 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 et al., 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 |
Table 4: Contd...

| Number | Reference                  | Country    | Number of patients (intervention: control) | Cancer type                          | Intervention                                                                 | Measures                                      | Results                                                                                                                                                                                                 |
|--------|----------------------------|------------|---------------------------------------------|---------------------------------------|------------------------------------------------------------------------------|-----------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 32     | Carlson et al., 2015[143]  | Canada     | 88 (34:36:18) MBCR/supportive-expressive Group therapy/stress management seminar Stage I-III distressed (BC) | inflammatory signaling               | Telomere length, mood, and stress                                          | 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 |
| 33     | Chakrabarty et al., 2015[144] | India      | 160 (80:80) BC patients who received radiation therapy | fatigue                               | Fatigue                                                                      | 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 |
| 34     | Cramer et al., 2015[145]   | Germany    | 40 (19:21) BC with menopausal symptoms      | fatigue                               | Primary: total menopausal symptoms                                           | 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                                                                 |
| Number | Reference | Country   | Number of patients (intervention: control) Cancer type | Intervention | Measures | Results                                                                 |
|--------|-----------|-----------|--------------------------------------------------------|--------------|----------|-------------------------------------------------------------------------|
| 35     | Derry et al., 2015\cite{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 et al., 2015\cite{147}  | USA       | 124 (62:62) Cancer unrelated pain                     | MIA          | Pain computerized intervention | 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 et al., 2015\cite{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. Both CBT-I and MBCR reduced insomnia severity and dysfunctional sleep beliefs and improved awareness. |
| 38     | Garland et al., 2015\cite{149} | Canada    | 72 (32:40) Cancer                                     | MBCR/CBT     | Mindfulness, dysfunctional sleep, and insomnia at baseline, post-program, and 3-month follow-up | Improved QOL, reduced depression and anxiety at post intervention. At 3-month follow-up, benefits were modest. |
| 39     | Grossman et al., 2015\cite{150} | Switzerland | 62 (33:29) HSCT                                        | MBI-version of MBSR, dynamic yoga | Primary: QOL Secondary: depression, fatigue, anxiety, and personal goal attainment | |
| 40     | Hughes et al., 2015\cite{151}  | USA       | 94 (31:31) BC                                          | Yoga based exercise program developed for this study (breath awareness, ranayama, Surya Namaskar, etc.) | Physical fitness, strength, flexibility, cardiovascular functions | Yoga improved physical fitness. |
| Number | Reference | Country | Number of patients (intervention: control) Cancer type | Intervention | Measures | Results |
|--------|-----------|---------|--------------------------------------------------------|--------------|---------|---------|
| 41     | Johns et al., 2015[152] | USA     | 35 (18:17) CS | 7 weeks MBSR intervention | Primary: fatigue Secondy: 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 et al., 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 et al., 2015[154] | USA     | 79 (38:41) BC | 6-week MBSR | Sleep parameters | Small nonsignificant improvements in subjective sleep parameters |
| 44     | Lengacher et al., 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 et al., 2015[156] | USA     | 30 (21 female: 9 male) (11:10:9) CS experiencing high levels of distress | MM/MBB/SHE | Improvement in sleep quality | |
| 46     | Long Parma et al., 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 et al., 2015[158] | UK      | 12 (4:4:4) Low-, medium-, and high-dose yoga in adult cancer patients | Low dose - 15 yoga instruction, 30 min pranayama and Satsang 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 |
### Table 4: Contd...

| Number | Reference          | Country   | Number of patients (intervention: control) Cancer type | Intervention | Measures | Results                                                                 |
|--------|--------------------|-----------|--------------------------------------------------------|--------------|----------|-------------------------------------------------------------------------|
| 48     | Peppone et al., 2015[159] | USA       | 167 (84:83) BC                                         | YOCAS        | Musculoskeletal symptoms among BC survivors receiving hormone therapy (AI or TAM) | Intervention significantly reduced general pain, muscle aches, and physical discomfort |
| 49     | Rahmani et al., 2015[160] | Iran      | 24 (12:12)                                             |              | FSS and QOL | Significant difference in QOL, emotion, social and cognitive dimensions, future perspective, and FSS |
| 50     | Rao et al., 2015[161]       | India     | 98 (45:53) BC patient undergoing conventional therapy |              | BDI       | A significant improvement in depression score, symptom severity, and distress |
| 51     | Sprod et al., 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 et al., 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 et al., 2015[164] | Turkey    | 52 (24:28) BC                                         | Yoga (asanas, pranayama, 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 |

*Contd...*
Table 4: Contd...

| 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 et al., 2016[166] | Germany | 54 (27:27) Nonmetastatic colorectal cancer | Primary: disease-specific QOL | 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 | Lötke et al., 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 | Pagliaro et al., 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 et al., 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. 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. 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 nonpharmaceutical 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 and a number of major cancer centers are adding integrative oncology in their programs. The prevalence, demographics, and trend of the use of yoga...
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

| 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
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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